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Workshop Proceedings

MANAGEMENT of North Central and Northeastern Forests for NONGAME BIRDS

January 23-25, 1979
Minneapolis, Minnesota

Compiled by
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PREFACE

In May, 1975, a symposium was conducted in Tucson, Arizona, on the management of forest and range habitats for nongame birds. That landmark meeting brought together avian ecologists and resource managers. It was widely agreed that both groups benefited each other, and that a series of regional workshops should be held. The objective of the series would be to insure that nongame bird habitat requirements are considered in significant land management practices, and that a diversity of natural biological communities are maintained.

To that end, the National Nongame Bird Steering Committee was formed to sponsor regional workshops to present the state-of-the-art of nongame bird research and management in various ecoregions of the United States. The first workshop in the series was held in Portland, Oregon, February 7-9, 1977, entitled, "Nongame Bird Habitat Management in the Coniferous Forests of the Western United States".

A second workshop in the series, "Management of Southern Forests for Nongame Birds", held January 24-26, 1978 in Atlanta, Georgia, presented bird habitat research results and management techniques for all major habitat types in the southern and southeastern United States. This third workshop is jointly hosted by the USDA-Forest Service--the Eastern Region; Northeastern Area, State and Private Forestry; and the Northeastern Forest Experiment Station; and the Northcentral Forest Experiment Station.

The Forest Service was joined by the National Nongame Bird Steering Committee in sponsoring this workshop. Its members include:

Forest Service, USDA
Soil Conservation Service, USDA
Fish and Wildlife Service, USDI
Bureau of Land Management, USDI
National Wildlife Federation
The Wildlife Society
Wildlife Management Institute
National Audubon Society
International Association of Wildlife Conservation Agencies

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Tuesday Morning, January 23

BIRDS IN FOREST ECOSYSTEMS

Moderator: Roger Holmes
Minnesota Department of
Natural Resources

MANAGEMENT OF NORTHCENTRAL AND NORTHEASTERN FORESTS FOR NONGAME BIRDS

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Foresters have begun to recognize their responsibilities for nongame birds, but that concern must manifest itself through professional management rather than preservation. The key to success will be diversity of habitats, which can only be achieved with advanced planning and knowledge acquired through research.

Four years ago, I participated in the first National Symposium on the Management of Forest and Range Habitats for Nongame Birds. The same thing that impressed me then impresses me now. As I told that audience in Tucson, the most significant thing about that symposium was its being--the fact that there was a national symposium on nongame birds. It was a first--a milestone in forestry-wildlife relationships. As John Gottschalk pointed out, this was the "opening skirmish in a revolution." "History will record what has been said here and by whom," I told the group, "and I am proud to have a small part in it."

That symposium in 1975, as well as this workshop today, represent a long-overdue recognition of our responsibility for all living creatures. But, as I told that audience then and will say again, let's meet our responsibilities fully and enthusiastically, but let's not allow this concern for nongame birds to play into the hands of those who would deny the use of all renewable resources

There is a growing and widespread philosophy that would prohibit the taking of any wild species, even the cutting of trees. This "reverence of life" philosophy is sincere and well-meaning, but it is a misdirected effort that will not achieve what its proponents seek. Nothing is so sure as the dynamics of nature. Change is inevitable. We can slow down, speed up, or guide that change, but we cannot arrest it at any given point in time. Preservation, as many would apply it, is actually counterproductive to those values they cherish most. We, as professionals, must preach the doctrine of "wise use" and resist the growing movement that would deny wildlife harvest to all and place most public forests into preserves and refuges.

As a forester, I am proud to see my fellow professionals taking an active role in this workshop. It shows a concern that we all feel even though it might now have been too evident in the past. Here are rough-and-tumble woods foresters talking about songbird habitats. That's progress!

Foresters have learned many valuable lessons, but, admittedly, have made many mistakes in the past. We are concerned about all wildlife, about the total ecosystem, about game and nongame species alike. We will not repeat mistakes of the past--massive clearcuts, careless logging, destruction of fragile sites. Forestry operations of the future will avoid unstable soils, high alpine types which cannot be quickly and successfully regenerated, and damages to streams and watersheds.

Recently, I heard an industrial forester describe most clearcutting of the past as "commercial hygrading," characterized by standing cull trees, broken trees, worthless species, and a tangle of logging slash. No wonder there has been great public outcry about this kind of clearcutting! His own operation in West Virginia utilizes total tree chippers--everything is used. It is a clean operation ready for replanting or natural regeneration. Maximum size of any clearcut is 25 acres and all are fitted into the landscape in an irregular pattern.

Even-aged management is good silviculture for both hardwoods and conifers. It has a definite place in our forestry future, but it must be less offensive and better planned than much of what we have seen in the past.

How do I see the role of the resources professional in nongame bird management? Essentially the same as his role in timber management or wildlife management for game species. I have been outspoken on this subject in the pages of American Forests, so this will not be new to most of you. But, here is my formula:

1. Probably the greatest need is diversity. We must provide and maintain variety of habitats. The importance of edge is well known to game managers, and it has equal value to nongame species. Too much of anything is not good, for man nor beast. I sympathize with those who express growing alarm over pine monoculture in the South or massive clearcuts in the West. Yet, I support judicial application of both practices. There is truth in the old Chinese proverb that the "excess of any virtue is a vice." Let's retain all management practices in our arsenal of tools, but let's maintain variety in their application.

2. The key to diversity and variety is planning. If we want to benefit nongame birds we must plan for their habitats. Too much of our resources planning in the past has been single purpose, for trees or game species, seldom for both, and almost never for the total ecosystem, including nongame birds. Opportunities are almost unlimited if forestry and wildlife professionals provide for all resources in their initial planning, not as an afterthought, but as equal partners in objective.

3. The key to planning is knowledge, or facts, and the only way to acquire them is through research. What do we know about nongame bird habitats? A lot more than we apply, I am sure, but not enough. The thing we don't know is how to optimize timber management, game management and nongame management, all on the same lands at the same time. Foresters have done excellent research on silvicultural methods to maximize timber production. Biologists are experts on ideal habitats for game species. And, I am sure we know a lot about nongame birds, but what do we know about the combinations? How much research has been done in northern forest habitats for renewable resources in total? Too little, I'm afraid, but I hope this workshop proves me wrong.

So my formula is diversity, planning and research. Until we achieve all three, nongame bird habitat management will be largely token or accidental. Sure, we will continue to burn some jack pines for the kirtland warbler, but what are we doing elsewhere? Do we really know what to do? There's a book I have been wanting to read on the passenger pigeon by A. W. Schorger. Everything I have heard about this vanished species was that we slaughtered them to extinction when they migrated in vulnerable flocks. According to Schorger, however, harvest had little to do with the disappearance of the passenger pigeon. We destroyed him when we changed his habitat. Maybe we created favorable habitat for another species, but wouldn't it be better if we had known before we did it? To me, that's what this workshop is all about. We've got to find better ways than we have used in the past. And, we have got to instill in all resource professionals a real sense of obligation and responsibility to all creatures, large and small, game and nongame, and nonprofitable as well as those that make us money.

Perhaps you have noted the overtone of professionalism I have injected in this keynote speech from the beginning. That is the one thing we must defend with all our strength. If we do not do our job as professionals, properly, we will lose the opportunity. The wave of preservation I spoke about earlier is born of fault and neglect. The protectionist is not pleased with our past performance. What he fails to realize, however, is that there is no substitute for applied management that only a professional can supply. What he seeks cannot be achieved by a "hands off" directive. His protective love can destroy the very thing he wants to preserve. But, we've got to convince him by action, not words. If we fail, then resource management decisions will be made by courts, by legislators, and in the ballot box rather than on the ground, the only place they can be made properly.

It should be obvious to all of you that I am not a nongame bird expert. I have little to offer this workshop except encouragement and motivation. Since I retired three weeks ago, I probably have lost any influence I might have had on legislation and appropriations. But, if I have a message it is a plea for tolerance and professional responsibility. Let's respect the beliefs and concerns of others, but let's also make sure we get our own house in order. There is a job to be done in recognizing, protecting, and improving the habitats of nongame birds. Let's be sure we do it, and do it right, or someone else will take over.

THE IMPORTANCE OF BIRDS IN FOREST COMMUNITIES

Richard L. Plunkett[1]

Abstract.--The usefulness of bird populations as monitors of the diversity of natural biological communities and to provide feedback to the manager as to the results of management programs is reviewed. Certain characteristics that contribute to the usefulness of birds as indicator species are discussed, and the need for reorientation toward ecosystem management in place of single-species management is stressed.

INTRODUCTION

When Richard M. DeGraaf prevailed upon me to accept this assignment, I was struck by the all-encompassing nature of the title of this paper, which is rather like the intellectual arrogance displayed by one of my professors at Northwestern University who published a book entitled simply "Man and his Works." He was an anthropologist, rather than an ecologist, which may offer an explanation though not an excuse. While it is true that ecologists are supposed to know how everything connects with everything else (Barry Commoner's First Law of Ecology), addressing this subject from a truly comprehensive standpoint lies way beyond my capabilities, and therefore I looked for a point of attack that would serve to simplify this paper and make it useful for the land manager.

One possible point of attack was that of the economic importance of birds in forest communities. The more I looked at this approach, the more difficult became the problem of how to quantify ecologic functions. That did not work.

A second point of attack would be to attempt to trace the cycling of energy through birds in forest ecosystems. Although this approach ultimately promises to be extremely useful, there is a real difficulty in drawing generalizations from the current studies that, given the present state of the art, must be restricted to relatively small plots in carefully delimited and relatively homogeneous habitats, so that this approach did not appear to offer anything of immediate practicality to the land manager.

A third point of attack would be to look at the importance of birds in forest communities in terms of their feeding ecology and its relation to insect population dynamics, perhaps examining the frequently cited role of birds in regulating the severity of outbreaks of defoliating insects. That looked promising, but when I reviewed those studies cited by Nisbet (1971), Wiens (1975) and Thomas et al. (1975), I found the evidence very much mixed. Briefly, it is apparent from those studies that birds consume only a small fraction (on the order of 1 to 7 percent, rarely as high as 14 percent) of defoliating caterpillars during the summer when insects are abundant, so that birds cannot be effective in controlling insect outbreaks in summer. Those studies also indicate, however, that birds may be capable of playing a substantial role in controlling insect populations in winter when the insects are sedentary. There are a number of studies indicating that in the winter birds may consume a much higher fraction (50 percent or more) of the insects found in a given area and thus could function to limit the number of insects emerging in the spring and hence to reduce the severity of summer outbreaks. Thus far, so good, but when I attempted to apply these findings, which are to a large measure based on European studies conducted in relatively small woodlots or on studies conducted in California and the Southwest, I noted that many of the insectivorous birds of our north central and northeastern forests are migratory and hence absent from our forests during the winter. In North America those species that depend on insects for food during the summer are the warblers, vireos, flycatchers, cuckoos, tanagers and chickadees, whereas the birds that depend on insects for food in the winter appear to be mainly the chickadees, nuthatches and woodpeckers. Where does this take us, except perhaps to emphasize the need for more intensive study of the feeding ecology of birds wintering in our forests, which may be useful but does not appear to be a particularly rewarding point of attack for this paper.

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This process of elimination left me with the approach for this paper that probably springs most naturally from my own work on behalf of the National Audubon Society---that of looking at bird populations, and especially at changes in bird populations, for what they can tell us about what is happening to the habitats on which they depend. Thus what I want to suggest in the remainder of this paper is that, to the land manager, the immediate importance of birds in forest communities may lie not in any of the ways of looking at birds outlined above, but rather that it may lie in the usefulness of birds as monitors of the diversity of natural biological communities, the habitats that the land manager is charged with preserving and enhancing.

USEFULNESS OF BIRDS AS MONITORS

If one reviews the Proceedings of the Symposium on Management of Forest and Range Habitats for Nongame Birds held at Tucson, Ariz., May 6-9, 1975, one will find a common, even dominant theme running through many of the symposium papers. This is that our lack of knowledge of the complex relationships, the interconnections, the interactive pathways of trophic web organization makes it extremely difficult for the land manager to manage habitats from a sound ecological approach. Now this is a valid statement, up to a point, but what I would like to suggest is that we may well turn the equation around, that we may look to the usefulness of bird populations (and changes in them) as monitors or indicators of how well we are doing in maintaining a diversity of natural biological communities. This is a conceptual reversal, in which we say not that the land manager has to have all that information in order to make wise management decisions, but that we may look to those bird populations (and changes in them) to provide useful feedback to the land manager as to the effects (on them) of his management programs.

Now this is a function that birds have been performing for man for centuries. Perhaps the prime example is the use of the canary carried in an open cage by the miner, which functioned as an efficient early warning system for the presence of mine gases and lack of oxygen (anoxia).

In more recent times a similar function has been performed by the birds of prey and certain other species, particularly the fish-eating birds, that feed at high trophic levels in long food chains. It is no accident that we have been forced to devote so much attention to studies of the raptors in recent years, no accident that the first indications of the effects of the organochlorine insecticides and related long-lived, fat-soluble compounds were found in the larger birds of prey such as the Bald Eagle _Haliaeetus leucocephalus_, Osprey _Pandion haliaetus_ and Peregrine Falcon _Falco peregrinus_. In each case it was the position of the species at the apex of a long food chain that gave the species its usefulness as a monitor of contamination in that food chain. I suspect that the same phenomenon can be cited to explain the relative differences we are now observing in other raptor populations, e.g., that it is probable that differences in the distribution and abundance of the Cooper's Hawk _Accipiter cooperii_ as compared to the Sharp-shinned Hawk _Accipiter striatus_ and the Red-shouldered Hawk _Buteo lineatus_ as compared to the Broad-winged Hawk _Buteo platypterus_ can be related to the size and type of prey species commonly taken by each of those raptors.

Similarly, it is partly because of their fish diet that so much attention has been devoted in recent years to the herons, egrets and ibis, the long-legged wading birds that have been doubly affected by the loss of wetland habitats and their tendency to accumulate toxins by virtue of feeding in aquatic ecosystems, and even more recently, to the gulls and terns, the short-legged wading birds that similarly serve as excellent indicators of contaminated food chains.

It might be helpful at this juncture to look at the reasons why birds are particularly useful monitors of environmental contaminants and, as I have suggested, also may serve as monitors of the diversity of natural biological communities. The class Aves has many special characteristics, including numerous adaptations necessary for flight and for specialization in feeding, but those of concern here might include the following: [2]

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[2] In developing this list of those avian characteristics that make birds especially useful as monitors of environmental contaminants and the diversity of natural biological

1. Birds are conspicuous, by virtue of the fact that they are largely diurnal, for most part live above ground, and must spend a considerable portion of the daily cycle in search of food.

2. The wide range of variation in bird size, the shape of the bill, neck, wings, legs and feet, and color variation in the plumage (reflecting the fact that like man and the primates they possess color vision) permits trained observers to identify many species in the field without having to resort to collecting.

3. Many species maintain territories, which further facilitates censusing them in the field, and particularly so in the case of the songbirds where the male sings to establish and defend his territory.

4. Birds are widely distributed through nearly all known habitats; as a class the Aves have a wider distribution than any other class of terrestrial vertebrates.

5. Birds are highly mobile, which means that their populations may rather quickly respond to perturbations in their food supply or to alterations in their habitats.

6. Many bird species are migratory and store fat before migration or in preparation for winter, thus accumulating stores of lipophilic (fat-loving) toxicants, which may have a delayed effect on mortality and hence be masked by displacement in the time and place of death because they are not mobilized until the fat is burned during migration or during a period of physiological stress.

7. Birds, like men, are warm-blooded, maintaining high internal body temperatures that in turn require maintenance of high metabolic rates; this means that birds must consume large quantities of highly nutritious protein-rich foods and hence may serve as high-volume food samplers.

8. In part to meet the demands of flight, birds have an efficient external respiratory system that is designed to handle large volumes of air; thus they may also serve as high-volume air samplers.

9. Some species absorb toxicants directly through their feet and hence may be susceptible to any airborne or air-deposited toxicants that may accumulate where they perch or walk.

10. Finally, more is known about the taxonomy of birds and more work has been done on their reproductive biology, life histories, behavior and physiology than has been done for almost any other class of terrestrial vertebrate.

It should be obvious that many of the characteristics that have made birds so useful as monitors of environmental contaminants may also make birds useful as indicators of change in forest ecosystems and as monitors of diversity in natural biological communities.

A further corollary of those characteristics is that they give us the capability of censusing bird populations rapidly, perhaps more rapidly than we can census other animal populations. The techniques by which we may census bird populations in forest ecosystems have already been established, and we can draw upon several existing data banks to establish baselines and to make the other comparisons necessary to interpret what is happening to bird populations in forest communities. These include the annual Breeding Bird Survey conducted by the U.S. Fish and Wildlife Service and the Breeding Bird Census and Winter Bird Population Study organized by the National Audubon Society and published annually in American Birds. Although the Breeding Bird Survey may be somewhat skewed toward edge-inhabiting species because of its dependence on roads, the Breeding Bird Census and Winter Bird Population Study constitute long-term data acquisition programs that offer a wealth of information as to the particular habitat requirements of many of the avian species that inhabit the northeastern and north central forests, and when these data are combined with what we already know of the life histories of nearly all North American birds, we have the basis for interpretation of responses of bird populations over the past 30 to 40 years to habitat alterations resulting from succession, logging, fire, windstorm, flooding, etc. Given these sources of information, which we can draw upon for both guidance and comparison, we should be able to determine which are the most useful indicator species for each forest community. I suspect that several of the papers to be presented at this symposium will identify key indicator species for various forest communities.

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communities, I drew heavily on an unpublished working paper, "Terrestrial vertebrate animals as biological monitors of pollution," prepared by Robert A. Lewis and Carolyn W. Lewis, Office of the Assistant Secretary for Environment, U.S. Department of Energy, Washington, D.C., as a contribution to the International Workshop on Monitoring Environmental Materials and Specimen Banking, Berlin, German Federal Republic, October 1978.

RELATION TO ECOSYSTEM MANAGEMENT

Earlier in this paper I suggested that we attempt to change our thinking, to make a conceptual reversal and focus not on how difficult it is to manage diverse habitats for nongame birds but rather to look to the bird populations themselves (and changes in them) to provide feedback as to how well or how poorly we are doing in managing forest habitats.

I also think that we need to recognize the implications of an attempt to manage forest communities for nongame birds, which is that, in order to accomplish this task without favoring one species or group of species at the expense of another, we must abandon single-species management and move toward ecosystem management.

To some extent this need to reorient our programs toward ecosystem management has been masked by other management directives that have come down the pike in recent years, most notably the requirements of the Endangered Species Act of 1973 and subsequent amendments. Just as many of us in the environmental and conservation communities were becoming aware that we could no longer practice single-species management to favor gamebirds and game animals without affecting nongame species, our attention was drawn to the need to devise special programs, based on single-species management, for endangered and threatened species. This is clearly required by the Endangered Species Act, as amended, in that any federal program or federally funded or permitted program is required by law to take into account the needs of endangered species and, in the case of federal land management agencies, to manage for them. But even this program of single-species management, however necessary, may now be approaching the point of diminishing returns as more and more endangered species are identified and listed. We have the capability for developing single-species management programs for a limited number of endangered or threatened species that occur in forest communities, but we may soon reach the point where what is necessary for one endangered species may conflict with what has to be done for another. Clearly, that point has already been reached in the Hawaiian forests, where the individual requirements of an entire assemblage of forest-dwelling endemic Hawaiian birds, all endangered, can only be met by attempting to manage the Hawaiian forest ecosystem as a unit, rather than attempting to devise separate single-species management programs for each of the endangered Hawaiian forest birds. I suspect that as we continue to develop the Endangered Species Program in North America and extend it to the flora as well as the fauna, it will become necessary to reorient that program more and more toward full ecosystem management.

There are certain other exceptions to the ecosystem management approach that spring to mind, most notably the need for special programs to meet the requirements of the birds of prey, special attention to meeting the requirements of cavity-nesting species in our forests, a high priority for the preservation of wetlands in our forest communities, and the need for special programs to deal with introduced or exotic species. Yet, if we are going to manage forest communities for nongame birds, we must, on the whole, reorient our programs from single-species management of our forests to an ecosystem approach, managing the forests for the benefit of all of their inhabitants and favoring no one group to the exclusion of another.

As my final point in this paper, I want to suggest that the only way in which we may successfully manage forest ecosystems for the benefit of nongame birds and all of their other inhabitants is to set as the principal objective of management for nongame species the maintenance of a high degree of diversity in natural biological communities. Let us return to that common theme that ran through so many of the papers at the Tucson symposium. If we accept the fact, as I believe we must, that we do, indeed, lack knowledge of all the interconnections (all of those interactive pathways of trophic web organization), we may be led to a very different conclusion: -----not that we cannot, for lack of that knowledge, manage forest communities for the benefit of nongame species, -----but that, precisely because of that lack of knowledge of all of those interconnections, we must manage for diversity, must do our best to preserve all of the elements of our forest ecosystems because we do not know enough to pick and choose among them. This is a cautious and profoundly conservative position, but it is supported by a considerable body of hypotheses and reasoning that, on the whole, suggests that diversity of natural biological communities may be our best protection against man-induced or natural perturbations of those ecosystems (Dearden 1978). This is drawn from the hypothesis----it is only a hypothesis but it is one that I find convincing---that the more diverse system, as contrasted to the less diverse system, has a greater capacity for self-restoration, precisely because it has a greater number of interconnections, interactive pathways, one or more of which may serve as the regulating and restoring mechanism.

If we take the maintenance of a high degree of diversity of natural biological communities as the principal objective of our management program for nongame birds, then the importance of birds in forest communities, to the manager, may well be that function outlined in this paper, that of supplying the feedback that the manager requires as an indication of just how well or how poorly his management programs are doing in meeting that objective.

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HABITAT STRUCTURE, SUCCESSION AND BIRD COMMUNITIES

Stanley H. Anderson[1]

Abstract.--Birds select habitats by several different mechanisms to supply the requisite needs of the species. Several statistical tests can be used to correlate bird species with habitat variables. Combining variables by means of factor analysis can indicate how species relate to forms of disturbance in forest habitats.

Natural changes in forest community structure that occur in plant succession can be altered by many human caused disturbances. These disturbances, which include fire, logging, increasing edge, retention of snags and maintaining a diverse habitat, are also effective tools for the manager of nongame birds.

INTRODUCTION

If you are a bird watcher you know that different species of birds are found in characteristic habitats. To find Barred Owls[2], for example, you go to hardwood forests in wet or swampy riverbottoms at night. The Black-backed Three-toed Woodpecker is found deep in coniferous forests where fire, logging or wind have left some standing snags with heavy understory. The Great Crested Flycatcher is often found in large woodlands with small openings and perch sites. The Red-breasted Nuthatch is wide ranging in mature evergreen forests whereas the White-eyed Vireo can be seen in the shrub and understory of southern forests and forest edge. The Black-and-white Warbler is found in mature forests and the Swamp Sparrow nests in bogs and marshes.

In North America there are 821 species of birds of which at least 225 species occur in the regions of concern to members of this Workshop. How can we manage for that large a number of species with their diverse needs? The key is to understand why species are found in a particular habitat, how habitat changes affect them, and how to manage for assemblages or communities of birds rather than individual species.

AVIAN HABITAT SELECTION

Why are birds where they are? Birds adapt to areas where their requisite needs are found. Their breeding habitat must supply all the needs, including nesting site, nesting material, food, and protection for each species. Within the evolutionary process, birds develop mechanisms enabling them to find these areas. When they arrive in their habitat they apparently instinctively perceive signals from the environment indicating their requisite needs are present (Klopfer and Hailman 1965, Wiens 1969) and do not attempt to breed in other habitats (Lack 1933). Some species of birds are known to imprint on the place of their birth. For example, Klopfer (1963) shows how Chipping Sparrows return either to the deciduous or coniferous forested areas around North Carolina depending on the particular forest in which they are born. Hilden (1965) summarizes several studies on gulls to show learning in habitat selection.

Since territorial animals seek their habitat rather than randomly disperse and settle through the environment, ethologists feel that structural features of the habitat provide "sign stimuli" (Lack 1933, 1937, Hilden 1965). These stimuli serve as forms or guideposts to indicate which habitats can be expected to supply the species' needs (Wiens 1969). It is most important to recognize that minor habitat alterations which destroy such "sign stimuli" can result in changes in bird species composition. Although a species might be found in a number of habitat types, the population in each habitat has characteristics that separate it from another. For example, when morphological characteristics of Red-breasted Nuthatches are examined in western Oregon, different bill and leg sizes are found in the fir and pine populations (Fig. 1) (Anderson 1976).

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[2] See Appendix 1 for scientific names of bird species discussed in paper.

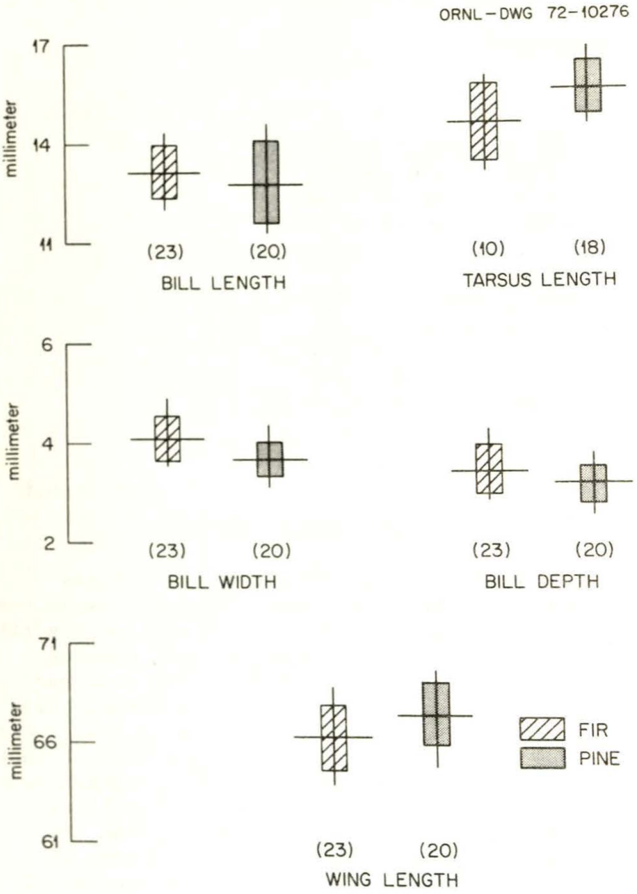

Figure 1.--Selected morphological characteristics of Red-breasted Nuthatches in western Oregon fir and pine forests. A two-tailed t-test shows a significant difference betwee the bill width, depth, and tarsus length. Horizontal line is the mean, rectangle represents the standard error, and vertical line the range.

Whereas most species seem to respond to the structure of the vegetation, other visual clues provide information about the habitat. Svardson (1949) indicates that water, overlooks, vegetation on the ground, and the shade of green influence the areas selected by some species of English birds.

Migratory birds do not begin to establish their territories or select nest sites until some weeks after they arrive in breeding habitat (Tinbergen 1961). Once birds have established their territory, they remain fixed to these sites despite frequent adverse conditions.

Emlen (1970) shows that bird counts in Florida pine stands are essentially the same in burned and unburned stands when fire burned the area during the breeding period.

Habitat structure, however, is the basic reason for the presence of birds in an area. Management of nongame birds, therefore, requires an understanding of the habitat structure and avian response mechanisms.

HABITAT CORRELATION

Information on the habitat of nongame birds can best be used by wildlife managers if it is translated into measurable features. Research biologists began to quantify habitat variables and correlate them with bird species in the late 1950s and 1960s. While more needs to be done on this subject, particularly in terms of seasonal and latitudinal differences, there are results that can be used by managers.

To describe avian habitat in Arkansas, James (1971) uses multivariate methods to indicate differences in vegetation variables. She points out that each species has a perceptual world to which it responds as an organized whole (niche-gestalt). This technique allows biologists to quantify the different vegetation components necessary for the species. Warbling Vireos are found in deciduous forests 40-100 feet tall that are relatively uniform in height and near the edge habitat. White-eyed Vireos show a preference for forests with mixed size class trees around 40 feet tall. Specific components can be listed for each bird species in the forest (Fig. 2).

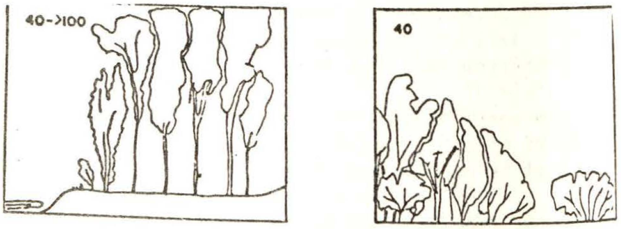

Figure 2.--Outline drawings of the niche-gestalt for the Warbling Vireo (left) and the White-eyed Vireo (right). Numbers give vertical scale in feet (from James 1971).

In another study using multivariate analysis, Anderson and Shugart (1974) show that Downy Woodpeckers in an east Tennessee deciduous forest are correlated with the number of saplings. White-breasted Nuthatches are correlated with understory vegetation and the biomass of trees in the lowest woody vegetation layer (Fig. 3). White-breasted Nuthatches

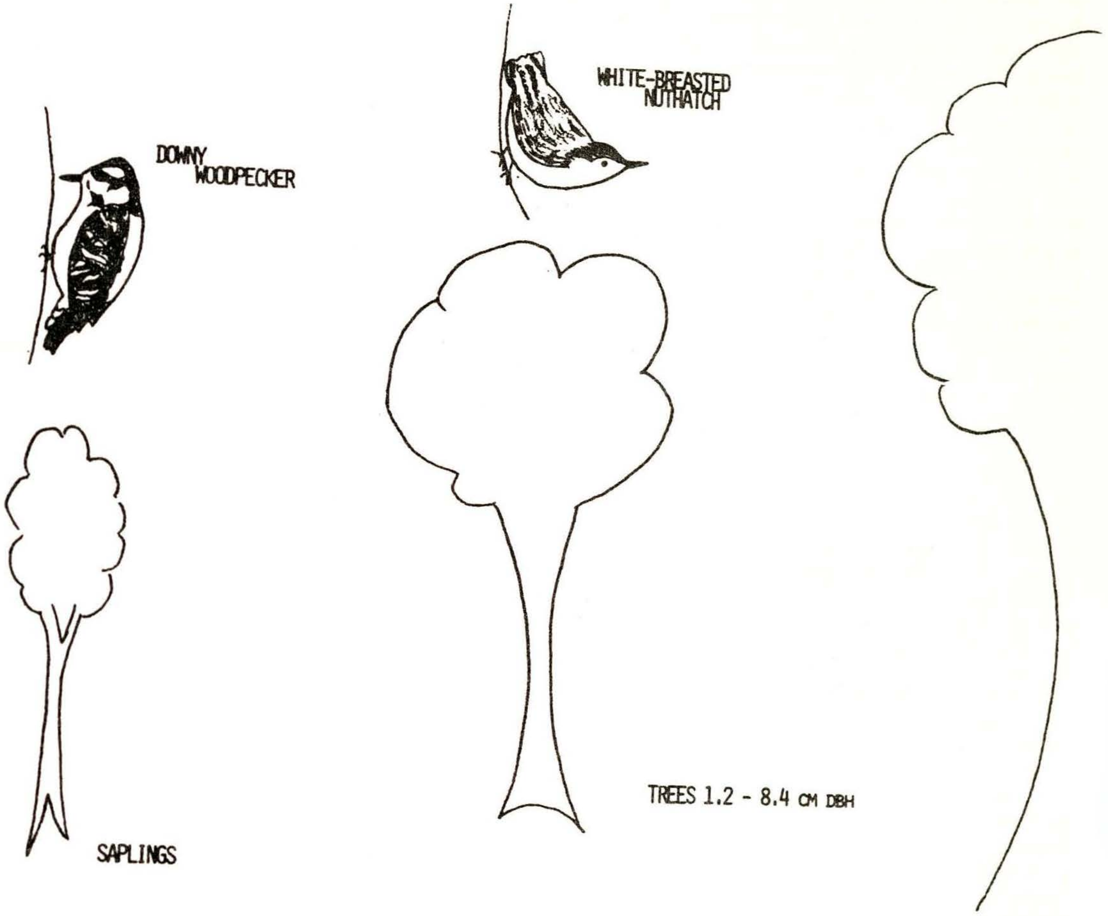

Figure 3.--Trees associated with Downy Woodpecker and White-breasted Nuthatch in east Tennessee deciduous forest (from Anderson and Shugart 1974).

and Downy Woodpeckers thus select their habitat using similar criteria. The distinction is that the woodpecker is found in areas with well developed understory whereas the nuthatch is in areas of sparse understory.

Whitmore (1975) used discriminant function analysis to determine important habitat variables for bird communities in Utah. He found that the percentage canopy cover was the most important individual habitat characteristic that could be used as a predictor of which bird species occupy a particular environment. The shrub density, number of trees 7.5 - 15 cm DBH and percentage ground cover followed in order of priority.

Ordination by means of principal component analysis is also possible as demonstrated by Smith (1977) in Arkansas. There he uses a combination of all habitat data to form the principal component axis. He found an ordination of birds along this axis with most species concentrated toward the moist forest.

Factor analysis is another statistical technique that is very similar to principal component analysis. Each test reduces the habitat variables in a multidimensional space to a linear component. Principal component analysis scales the variables so that the sum of the squares for the element in each vector equals one. When this is done the associated eigenvalue (characteristic root) is interpreted as the variance along the principal component axis. Vectors in factor analysis are scaled so that the coefficients are the correlation coefficients with the original measurements.

Factor analysis was used to evaluate the habitat of breeding birds in the Upper

Peninsula of Michigan. The purpose of this study was to evaluate the effect of a wildfire that burned over 260 square kilometers on the Seney National Wildlife Refuge in 1976. Seven paired eight-hectare plots, one of each pair on burned and one on unburned habitat, were established to conduct the evaluation. Two major habitats, the northern mixed forest and the bog/fen, were burned on the Refuge. The mixed forest consisted of a few pure stands of black spruce (*Picea mariana*), paper birch (*Betula papyrifera*) and quaking aspen (*Populus tremuloides*). There were many areas where the forest was quite open and trees sparse, allowing dense concentrations of alder to grow. Most of the region consisted of a mixture of aspen, cherry, spruce, maple, pine, fir and birch.

The fire burned in a very erratic manner. In some places it destroyed virtually all of the standing timber. In other places the fire simply burned in and around the bottom of trees, destroying some of them. In the spring following the fire, seedlings of quaking aspen and jack pine (*Pinus banksiana*) as well as lowbush blueberry (*Vaccinium augustifolium*) and bracken fern (*Pteridium aquilinum*) grew on the burned ground. By the spring of 1978, two years after the fire, the ground had a rich cover of aspen seedlings and blueberry.

On the Seney Wildlife Refuge, the bog habitat was covered by a thick layer of peat resting on sandy soil. The area had long (up to 2 kilometers) dense bog forests that were less than 0.25 kilometers wide. Tamarack (*Larix laricina*) and red maple (*Acer rubrum*) were the common tree species. Between the forests were flat bogs containing typical bog plant species as well as short tamarack and bog birch (*Betula pumila*). Fire burned rapidly through some of these areas, destroying the trees, grasses, sedges, and the upper layers of peat. Interspersed in the open bog areas were small sand islands less than 0.04 hectares with populations of red and white pine or aspen and birch. Most of the sand islands were no larger than a hectare.

Each plot was censused for breeding birds eight times each spring in 1977 and 1978. All birds heard and seen were recorded. The vegetation data were collected on ten 0.04-hectare points randomly selected within the plots by means of a modified James and Shugart (1970) method.

An ordination of the plots (Figs. 4, 5) was constructed by a principal axis factor analysis of the habitat variables with a varimax rotation (Overall and Klett 1972, Greg-Smith 1964, and Barr *et al.* 1976). Unrotated principal axis factors only differed for principal components by a scaling factor. Varimax rotation was used to obtain a simple structure that was easier to interpret. The factor scores for the variables on Table 1 allow the selection of the most significant variables.

An examination of the loading of the first factor shows that it represents the mature forest, with a strong positive correlation to the number of trees, the percentage canopy closure, and the mean canopy depth (high values for this variable indicate the presence of conifers). The second factor represents the effect of the burn and has a high positive correlation with the number of snags and the number of seedlings. The most marked change on burned plots between the first and second growing seasons after the fire is the high number of seedlings, mainly aspen (*Populus tremuloides* and *grandidentata*), that become established on the charred soil. High numbers of seedlings on unburned plots are due to advanced reproduction. The third factor represents the shrub component of the vegetation. The factor scores for variables on each plot can be examined (Table 2) and compared with the composite scores (Table 1) to determine the variation of the plot from the mean.

Figure 4 shows the two dimensional ordination of plots in the space of the habitat factors. The burned and unburned plots are best separated on the basis of factors one and two. All unburned plots except 6 and 7, which are located in the relatively open bog/fen, have positive scores for Factor 1. Burned plots 6 and 7 likewise have negative values for Factor 2. The dead trees of plot 6 are not standing as snags because the supporting root systems are burned away. The burn on plot 7 is not severe and has little effect on the bog shrubs and the few small trees. When Factor 3 is added (Fig. 5), burned and unburned plots 6 are clearly separated. There are high numbers of bog and lowland shrubs on the unburned plot of the pair; however, recovery cannot occur quickly because the shrubs and top layers of peat are burned away. Two years after the fire, only sedges (*Carex* sp.) and cotton grass (*Eriophorum* sp.) are established.

Burned plot 4 stands out as having scores close to zero for all factors. A smaller (72%) portion of this plot burned with a less intense fire. Consequently fewer trees are dead. The living trees give this plot a higher percentage of canopy closure than several of the unburned plots.

The factor score for each bird species is determined on the basis of weighted variables of the plots where the species is found (Table 3). Selected bird species are added

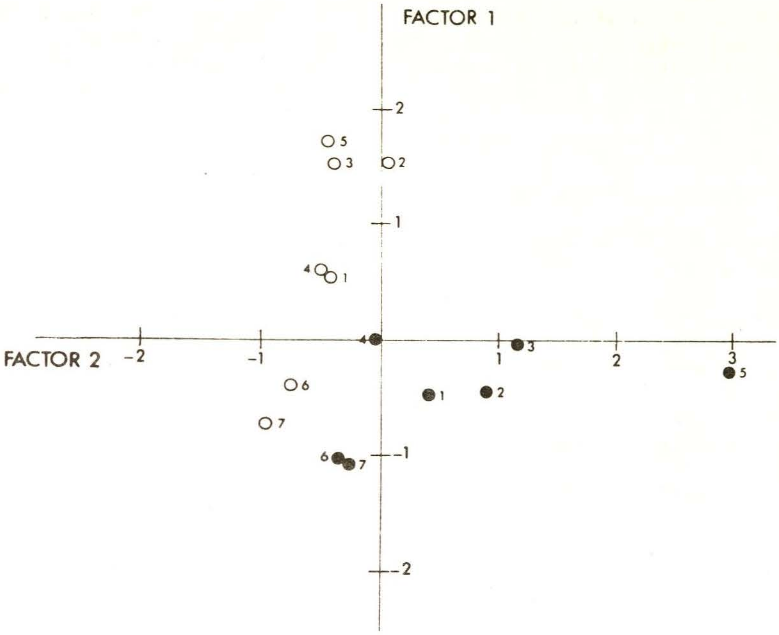

Figure 4.--Ordination of 20-acre plots on Seney National Wildlife Refuge in space of habitat factors 1 and 2 formed by a principal axis factor analysis with a varimax rotation. Dark circles represent burned plots, light circles represent unburned plots.

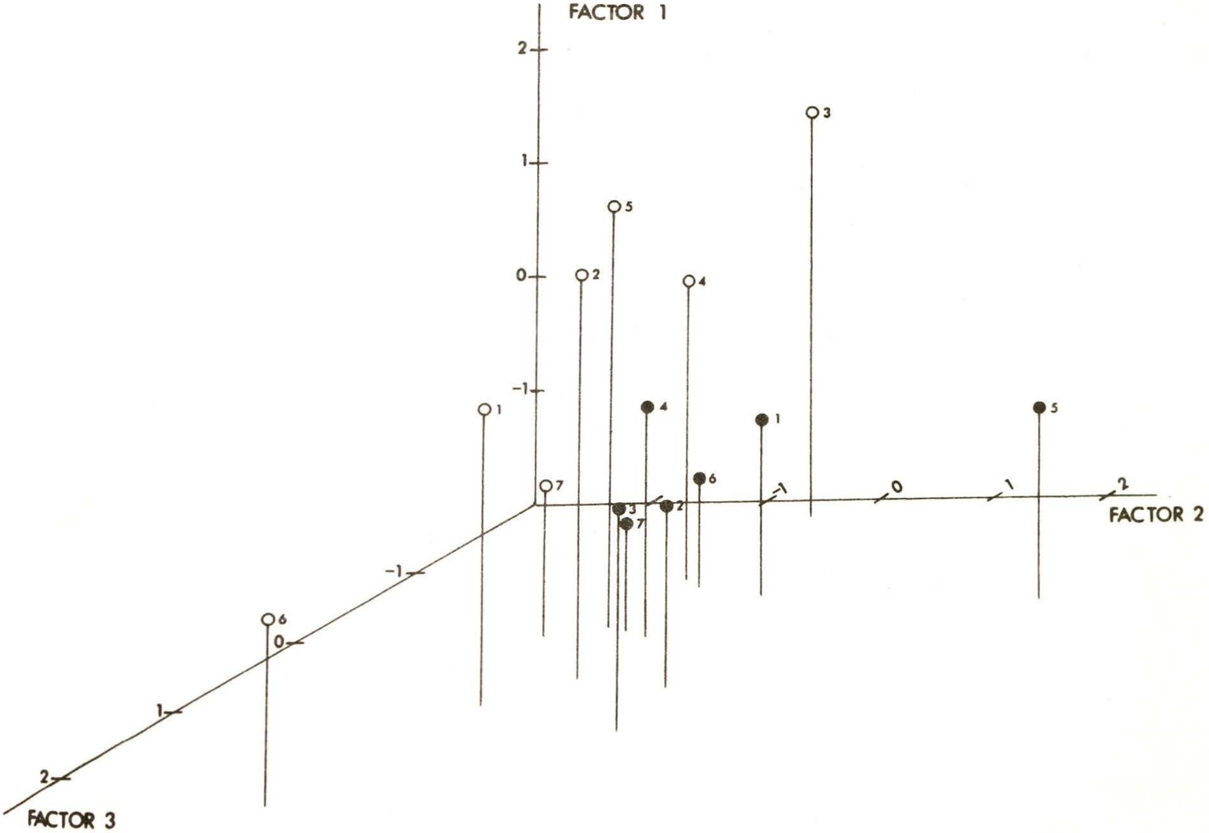

Figure 5.--Ordination of Seney plots as discussed in Figure 4 in space of factors 1, 2 and 3.

Table 1.--Habitat factor loadings (correlations with observed habitat variables) for the principal axis factor analysis with a varimax rotation.

	Factor 1	Factor 2	Factor 3
Trees 24-44 cm DBH	0.7367	-0.0107	-0.3713
Trees < 24 cm DBH	0.8180	-0.0780	-0.1465
Shrubs 50-150 cm tall	-0.1730	-0.0656	0.8408
No. saplings	0.5732	0.0928	0.6400
No. seedlings	0.0042	0.8564	0.1288
No. snags	-0.0312	0.8751	-0.1400
% of plot burned	-0.6004	0.5534	-0.1087
% canopy closure	0.9521	-0.0403	0.0148
Mean canopy depth (meters)	0.9417	0.1408	-0.0795
% cover - grasses and sedges	-0.5936	-0.6002	-0.0170

to Figure 6 by using the weighted variables. Species such as the Savannah Sparrow found only on burned plot 6 have the same factor scores as that plot. Bird species found on several plots are clustered in the center of the figure. The Black-backed Three-toed Woodpecker, strongly influenced by the presence of conifer snags, is located far to the right on the figure, with a high positive score for Factor 2. Species using plots with high numbers of trees (e.g., Cape May Warbler and Ovenbird) have a high positive correlation with Factor 1, represented by the vertical line supporting the species symbol on the figure.

Management for nongame birds can be most effective when the key habitat components associated with each community are known. While a number of biologists show that an increase in the structural complexity of a community is associated with an increase in bird species (MacArthur and MacArthur 1961; MacArthur, *et al.* 1966; Karr 1968), the effect of habitat change must be evaluated in terms of individual or groups of habitat components.

PLANT SUCCESSION AND BIRDS

Plant succession occurs, according to McIntosh (1970), because most species are temporary occupants of a site. Plants tend

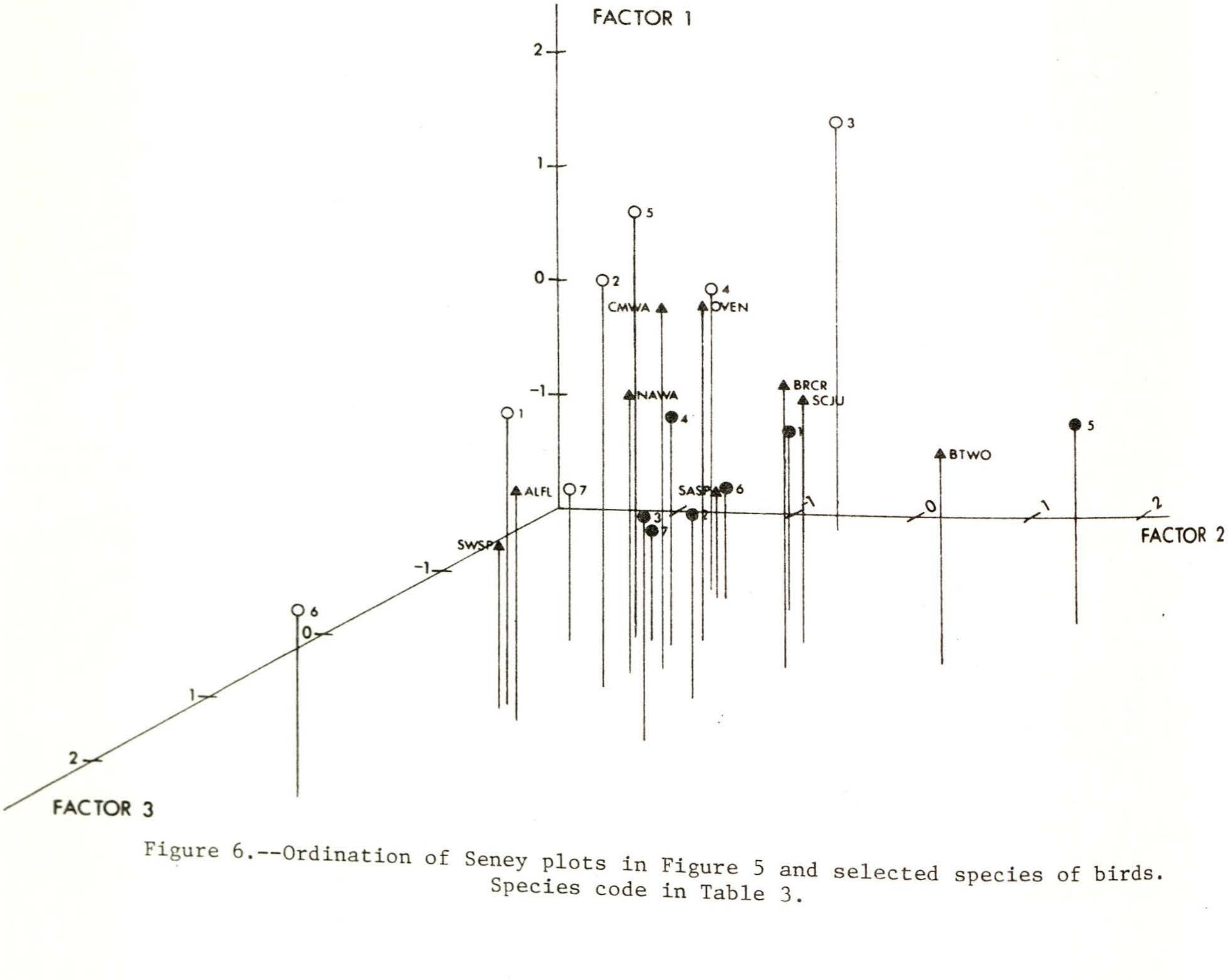

Figure 6.--Ordination of Seney plots in Figure 5 and selected species of birds. Species code in Table 3.

Table 2.--Factor scores and observed habitat variables for plots.

	UNBURNED						
Plot number	1	2	3	4	5	6	7
Factor 1	0.52	1.53	1.52	0.64	1.74	-0.37	-0.73
Factor 2	-0.43	0.05	-0.41	-0.52	-0.42	-0.77	-0.90
Factor 3	0.97	0.66	-1.76	-0.77	-0.12	2.46	-0.01
Trees 24 - 44 cm DBH	6.00	16.00	65.00	13.00	15.00	0.00	0.00
Trees < 24 cm DBH	183.00	364.00	113.00	167.00	604.00	124.00	4.00
Shrubs 50 - 150 cm tall	1928.00	808.00	48.00	224.00	728.00	7224.00	1504.00
No. saplings	68.00	72.00	20.00	16.00	32.00	32.00	16.00
No. seedlings	1040.00	6400.00	160.00	80.00	40.00	80.00	240.00
No. snags	25.00	25.00	19.00	11.00	32.00	19.00	0.00
% of plot burned	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% canopy closure	24.50	70.50	45.00	31.00	59.00	17.20	0.20
Mean canopy depth (meters)	6.23	7.38	10.06	7.83	9.55	2.36	0.86
% cover - grasses & sedges	22.50	11.80	3.00	11.20	2.10	33.20	40.00

	BURNED						
Plot number	1	2	3	4	5	6	7
Factor 1	-0.49	-0.42	-0.01	0.01	-0.26	-1.07	-1.10
Factor 2	0.38	0.87	1.16	-0.09	2.95	-0.32	-0.28
Factor 3	-0.61	0.81	1.45	0.05	-0.42	-0.73	-0.08
Trees 24 - 44 cm DBH	3.00	2.00	9.00	12.00	9.00	0.00	0.00
Trees < 24 cm DBH	39.00	45.00	54.00	97.00	87.00	3.00	2.00
Shrubs 50 - 150 cm tall	736.00	1744.00	3472.00	2808.00	1240.00	624.00	2352.00
No. saplings	8.00	56.00	72.00	12.00	4.00	0.00	0.00
No. seedlings	2960.00	8040.00	6200.00	680.00	18720.00	320.00	0.00
No. snags	53.00	52.00	112.00	39.00	360.00	4.00	0.00
% of plot burned	100.00	94.50	100.00	72.00	79.50	100.00	100.00
% canopy closure	13.50	7.50	9.20	29.30	16.50	0.50	0.20
Mean canopy depth (meters)	3.77	2.55	6.28	6.04	4.56	0.60	0.44
% cover - grasses & sedges	12.60	10.70	3.10	18.70	2.20	33.80	26.40

Table 3.--Factor scores for bird species.

Species (code)	Factor 1	Factor 2	Factor 3	Number territories
Alder Flycatcher (ALFL)	0.0931	-0.1498	1.2255	7.5
Brown Creeper (BRCR)	0.4900	1.2293	0.3025	3.0
Black-backed Three-toed Woodpecker (BTWO)	-0.1769	2.3538	0.2003	1.5
Cape May Warbler (CMWA)	1.1510	0.1942	0.3266	22.0
Nashville Warbler (NAWA)	0.4335	0.0274	0.4434	39.0
Ovenbird (OVEN)	0.8609	0.1386	-0.0883	33.0
Savannah Sparrow (SASP)	-1.0686	-0.3196	-0.7346	3.0
Slate-colored Junco (SCJU)	0.1510	1.0649	-0.0884	13.0
Swamp Sparrow (SWSP)	-0.3254	-0.4421	1.0933	9.5

to invade an area when the resident species change the habitat so the residents cannot effectively compete with invaders. Actual stages of plant succession might or might not coincide with distinct bird communities as birds respond to structure.

In a study in the Algonquin Provincial Park in Ontario, Martin (1960) reported that birds occurred when their niche requirements were satisfied. Martin pointed out that you could list a group of birds for each forest type in the park, but most species overlapped into several plant community associations. He also showed that bird species were found in different vertical strata in the different plant communities.

On the Apostle Islands of Wisconsin, distinctive patterns of hemlock, pine, aspen, red oak, sugar maple, and percentage of understory contribute to the bird species diversity (Beals 1960). The lack of pattern for spruce and fir could reflect the important difference of associated tree species according to Beals. This lack of pattern is particularly true of the northeastern and north central forests. Kendeigh's 1948 study on the northern lower peninsula of Michigan shows that plant communities there have a very non-uniform structure. In that study, aspen--red maple forests contain two bird communities and red pine--aspen, a mingling of three bird communities. This information, he points out, is an indication that bird species do not directly recognize the same seral stages as plant communities.

Most workers find that avian species and diversity increase through progressive successional communities toward climax vegetation (Johnson and Odum 1956, Shugart and James 1973). These results are similar in both deciduous and coniferous forests. Karr (1968) notes a slight decline in bird species and in density in late forest stages. Bond (1957) used a vegetation continuum index devised by Curtis and McIntosh (1951) to correlate populations of breeding birds to tree species composition. This study in southern Wisconsin has obvious relationships to community succession. It also shows how bird species and diversities change in different stages of succession.

Logging and fire are two forms of habitat destruction to which succession can be related. Fire historically serves as an important factor in the regeneration of forests of the north central region. Following fire an area generally reverts to an early stage in succession. Adams (1908) shows the importance of fire in maintaining open areas on Isle Royale, Michigan. Niemi (1978) shows that bird species, especially small passerines, decrease following fire in northern Minnesota. The study at the Seney National Refuge indicates that some bird species are attracted to burned areas and others leave the disturbed areas (Table 4).

Table 4.--Bird species on Seney National Wildlife Refuge significantly affected by the 1976 fire.

Increased following fire:	Decreased following fire:
Eastern Kingbird	Veery
Brown Creeper	Black-and-white Warbler
Cedar Waxwing	Magnolia Warbler
White-throated Sparrow	Cape May Warbler
Song Sparrow	Chestnut-sided Warbler

These data, developed by means of an analysis of variance test, show that 10 species of birds are affected by the fire. In addition, in the mixed forest the Alder Flycatcher, Black-throated Green Warbler and Nashville Warbler are common in the unburned area, while the Yellow-rumped Warbler, American Robin, Lincoln's Sparrow, Killdeer and Black-backed Three-toed Woodpecker are observed most frequently in the burned forest.

The bog forest has American Redstart, Black-and-white Warbler, Canada Warbler, Nashville Warbler and Swamp Sparrow, which are not found in the burned bog area. The only species found in the burned bog area and not in the unburned area are Savannah Sparrow and Brewer's Blackbird.

Birds moving into burned areas are probably attracted by features such as snags which attract woodpeckers and bark-foraging species and perches for insect hawking species. Succession following a fire can increase the diversity of birds as the shrub layer thickens below the burned snags, and seedlings and shrubs develop rapidly in the area. Heinselman (1973) stated that the entire biota of the Boundary Waters Canoe Area of Minnesota are adapted to periodic fire. Succession resulting from fire restructures the entire system.

Bird species diversity on the Seney Refuge was higher on the burned plots than on the unburned plots. Species such as the Black-backed Three-toed Woodpecker, Brown Creeper and Slate-colored Junco, which were uncommon in burned areas, were found in the burned habitat. Very few species were found exclusively in the unburned habitat although the populations found in dense forests were lower than in the burned habitat.

Clearcutting, on the other hand, destroys segments of the forest creating open areas with much debris on the ground. When whole forests are destroyed, as occurred in northern Minnesota and Wisconsin in the early part of the century, the avian community changes.

In a study on five stands of northern hardwood forest in the Adirondack Mountains of northeastern New York, breeding bird census sites were established to verify the effect of logging. None of the bird species were eliminated by logging, but some were recorded only in logged stands (Webb *et al.* 1977). They found that in this 10-year study the number of species and the species diversity index increased in the logged areas and were correlated positively with logging. Hagar (1960), in a study of Douglas fir (*Pseudotsuga taxifolia*) in California, found that little change occurred in the number of species immediately following logging. He indicated that a change occurred in the species composition 3 years following logging.

Natural succession should be considered in nongame bird management. Total diversity can be maintained at a higher level when forests consist of different successional seres. Habitat change can be planned around the forest succession sequences and the nongame bird communities.

MEASUREMENT OF CHANGE IN BIRD COMMUNITIES

It is important to be able to measure the changes in bird communities as they occur in a forest.

Diversity. A bird species diversity index (BSD) can be one means of measuring change. Diversity is measured by counting the number of individuals and the number of species, then noting the distribution of individuals among the species. Thus communities with low BSDs tend to have large numbers of birds in one or a few species and very few individuals in other species. Communities with high BSD have a more or less uniform distribution of individuals in all species. To use diversity indices it is important to have comparative figures. Thus the BSD of different successional seres might be compared. Diversity before and after disturbance can be used. MacArthur and MacArthur (1961) show how BSD increases with the diversity of the vegetation in the three different layers (foliage height diversity - FHD) they use. Habitats with more uniform distributions of tree, shrub and ground layers contain higher bird species diversities. Willson (1974) cautions about using such indicators after finding a lack of correlation between BSD and FHD.

Wildlife managers, however, can use the diversity concept to maintain nongame bird communities. By measuring BSD in a forest and maintaining important habitat factors correlated with key species, it is possible to maintain diverse communities. Habitat diversity is an approach that can be contrasted with single species management of game or endangered species.

Care should be taken in using the diversity techniques as all bird species contribute to the diversity. Thus, some less desirable species, such as Starlings and House Sparrows, or highly adaptable species such as Gray Catbirds and Cardinals, are able to substitute for some of the more specialized species of forest birds. Studies should be made on carefully delineated communities. The clue is to establish a habitat for the bird community desired and use diversity as one of the tools of measurement.

Indicator Species. Species that characterize a community are indicator species. While it is difficult to define this term because there are so many species in a community, it is possible to identify major bird assemblages with each successional sere. The changes that occur as succession proceeds in a forest make it possible for us to look at different birds that are found in different community types. Bird species frequently overlap between two plant seres so bird communities do not always coincide with plant communities. However, by managing for the selected bird species found in each seral stage we can attract an entire community. We must still be sure that minor or endangered populations are not lost because of our effort. It is important to realize that management for indicator species means managing for the whole community. It is also possible to use one of the lesser or endangered populations as an indicator.

Data from the Seney National Wildlife Refuge and data from Martin's (1960) study in Ontario, Canada, are used to show key indicator species in bog, boreal forest and deciduous forest communities (Table 5).

NONGAME BIRD MANAGEMENT IN THE NORTH CENTRAL FORESTS

Managers have a number of techniques available to them for managing nongame communities.

Table 5.--Common birds of bog, boreal forest and deciduous forest in north central United States (source, Martin 1960 and Anderson unpublished data).

Bog	Boreal Forest	Deciduous Forest
Eastern Kingbird	Spruce Grouse	Eastern Wood Pewee
Tree Swallow	Golden-crowned Kinglet	White-breasted Nuthatch
Common Yellowthroat	Ruby-crowned Kinglet	Wood Thrush
Red-winged Blackbird	Cedar Waxwing	Veery
Lincoln's Sparrow	Magnolia Warbler	Red-eyed Vireo
Swamp Sparrow	Myrtle Warbler	Ovenbird
Song Sparrow	Northern Waterthrush	Scarlet Tanager
	White-throated Sparrow	Rose-breasted Grosbeak

Fire. Much of the north central forest region was periodically affected by fire before white man. Fire largely determined the composition and structure of the presettlement vegetation in such areas as the Boundary Waters Canoe Area, the Upper Peninsula of Michigan, and a good portion of northern Wisconsin and Minnesota. These fires burned in irregular patterns throughout the area, opening up the understory, creating additional edge, and thereby creating habitat for many bird species.

Some species, such as the Kirtland's Warbler, are dependent on fire for periodically opening habitat. A number of other species, including Upland Sandpiper, Mourning Dove, Common Nighthawk, Common Flicker, Eastern Kingbird, Black-capped Chickadee, House Wren, Brown Thrasher, Eastern Bluebird, Nashville Warbler and Vesper Sparrow, are reported by Pinkowski (1977) to receive benefits from jack pine burns in Michigan. Studies by Heinselman (1973) and Niemi (1978) also demonstrate the effect of fire on birds in the north central region.

A small prescribed burn can be used to clear the understory or some of the ground litter and allow ferns and aspens to spring up to provide seed and other food for birds. Larger burns can be used to actually change the structural component of the vegetation. A very intense fire could destroy the entire forest and set the area back to the earliest stages of succession. Intense fires are much more common in the western United States.

Clearing Vegetation. Selective logging, clearing understory and removing small stands of timber all have major impacts on the avian community. They all serve to increase bird diversity in the north central forest. They attract edge species and provide a temporary mixture of both forest specialists and edge generalists. Flycatchers can hawk in the open area and woodpecker activities increase on the more exposed tree and snag branches. Clearing the understory allows some species to move into forested areas previously unavailable to them because of dense vegetation. This technique is particularly effective when the habitat requirements of bird communities are considered for each successional sere.

Edge. A number of studies have shown the value of edge to birds. Lay (1938) indicated that wildlife increased in a mixed Texas forest where small clearings were established. Hagar (1960) found that logging in a western Douglas fir forest increased the bird population density along the edge within 3 years after cutting. Johnson (1947) believed that the forest edge was a distinct community because it was inhabited by species that in part displayed adjustments to the particular niche available only in forest edge. Kendeigh (1946) documented the high species diversity in the deciduous-coniferous forest ecotone.

Managers can use the edge concept to maintain the diversity of the north central forest birds. Another paper in this Workshop addresses the dangers of introducing edge into forest interior situations and discusses the minimum edge-free area required to support different species of forest interior birds. This very important feature should be considered when deciding whether to manage avian communities by increasing edge. Increased edge can actually reduce the number of nongame species if the forest becomes fragmented into small isolated units.

Using these guidelines, one should consider edge between forest and field or edge created by human disturbances such as logging, transmission-line corridors and roadways. These cuts are continuing to increase the amount of edge and reduce the size of unbroken forested area. A study in an east Tennessee deciduous forest shows that transmission-line corridors reduce the area for nesting migratory bird species but increase the nesting potential for resident birds (Anderson in press). The additional open area brings in some gallinaceous birds, as well as the raptors and other predators, which can hunt along these transmission lines.

Snags. Snags or dead trees are considered undesirable by many land managers and are viewed with mixed emotions by wildlifers. We now are aware of some 85 species of North American birds that excavate nesting holes or use holes created by other species in dead or deteriorating trees (Scott *et al.* 1977). Since the majority of all cavity nesting birds are insectivorous, they play a valuable role in the forest ecosystem. Maintenance of snags does benefit hole-nesting species (Haapanen 1965).

The great majority of hole-nesting species are permanent residents or short distance migrants (owls, woodpeckers, chickadees, nuthatches, wrens and bluebirds). Another paper in this Workshop will address some problems associated with leaving snags standing throughout a forest.

Nest boxes can be substituted for snags to draw more cavity nesters or increase their nesting success. Game biologists attract wood ducks, mergansers and a few other species by properly placing nest boxes. Experiments with some species of chickadees show population increases when nest boxes are placed in wooded areas with insufficient nesting cavities. We need to conduct studies on the behavior of species using nesting boxes to determine how far apart they should be placed for maximum utilization.

Habitat Diversity. Very few areas have extensive uniform avian habitat; rather, small islands of forest are found around fields and forests are segmented by roadways and clearcuts. Succession can also vary due to slope, exposure, climate and historical use. Uniform forests such as those found on tree farms often have a lower bird species diversity than those with a mixed age class. Forests having a diversity of structure generally attract the largest bird diversity.

Planned Management. Effective management for nongame birds requires a plan based on desired goals and specific methods.

Once the area to be managed is selected and the purpose for management established, employable methods to fulfill that purpose must be chosen. One management possibility could involve allowing the area to proceed toward natural succession and climax--a policy of let nature take its course. The result is likely to be an increase in diversity and changes in the bird species much as would occur in a climax vegetation. The population or diversity of birds is highest in the near climax communities. If a large region is allowed to reach climax forest, total diversity and species composition will be reduced. Second, the area can be maintained for diversity by special techniques, such as clearcutting the understory, prescribed burns, or some profitable form of logging. Management of an area under these principles really is the development of a sustained yield plan or a plan that alters the different areas at different times. Third, single species management might be instituted for important species, endangered species or others. Finally, selective techniques discussed in this paper might be used to maintain nongame bird communities in habitats managed for other purposes, such as timber harvest.

The manager must consider the size of the habitat that is being managed and the natural successional sequence. In addition, unusual species must be considered. It is difficult to attract rare or unusual species to a forest habitat by selective management. Knowledge of the habitat requirement of the avian community and major species make for the most effective management of the north central forests for nongame birds.

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APPENDIX 1

Common Name	Scientific Name
Killdeer	*Charadrius vociferus*
Barred Owl	*Strix varia*
Downy Woodpecker	*Picoides pubescens*
Black-backed Three-toed Woodpecker	*Picoides arcticus*
Great Crested Flycatcher	*Myiarchus crinitus*
Alder Flycatcher	*Empidonax alnorum*
White-breasted Nuthatch	*Sitta carolinensis*
Red-breasted Nuthatch	*Sitta canadensis*
Brown Creeper	*Certhia familiaris*
Gray Catbird	*Dumetella carolinensis*
American Robin	*Turdus migratorius*
Starling	*Sturnus vulgaris*
White-eyed Vireo	*Vireo griseus*
Yellow-throated Vireo	*Vireo flavifrons*
Warbling Vireo	*Vireo gilvus*
Black-and-white Warbler	*Mniotilta varia*
Nashville Warbler	*Vermivora ruficapilla*
Cape May Warbler	*Dendroica tigrina*
Yellow-rumped Warbler	*Dendroica coronata*
Black-throated Green Warbler	*Dendroica virens*
Kirtland's Warbler	*Dendroica kirtlandii*
Ovenbird	*Seiurus aurocapillus*
Canada Warbler	*Wilsonia canadensis*
American Redstart	*Setophaga ruticilla*
House Sparrow	*Passer domesticus*
Brewer's Blackbird	*Euphagus cyanocephalus*
Cardinal	*Cardinalis cardinalis*
Savannah Sparrow	*Passerculus sandwichensis*
Slate-colored Junco	*Junco hyemalis*
Chipping Sparrow	*Spizella passerina*
Lincoln's Sparrow	*Melospiza lincolnii*
Swamp Sparrow	*Melospiza georgiana*

NORTHEASTERN AND NORTH CENTRAL FOREST TYPES AND THEIR MANAGEMENT

Lewis F. Ohmann[1]

ABSTRACT.--A brief background is given of the forests of the north-central and northeastern United States. Then, the major forest types, typical timber management objectives, and common silvicultural practices used in these forests are described.

Management of forests of the north-central and northeastern United States for wood products affects a wide variety of habitats for nongame birds. Therefore, a familiarity with the major forest types and how they are managed is desirable to fully understand these forests as habitats for nongame birds. This report briefly outlines the major forest types, the principal forest products, and the typical silvicultural practices of this region.

BAILEY'S ECOREGION CLASSIFICATION

Because many of the forest types occur over the entire area--for example, northern hardwoods are found from Minnesota to the east coast--I will use Bailey's (1978) hierarchial classification system (ECOREGION) to characterize the region in broader, more generalized terms before describing the types. In Bailey's system, the north-central and northeastern United States are classified within the Humid Temperate Domain (fig. 1); a mid-latitude zone where the presence of both tropical and polar air masses cause large seasonal changes in temperature and precipitation. Forests are a mixture of evergreen needleleaf and deciduous broadleaf trees (Bailey 1978). The Domain is subdivided into two areas--the Warm Continental and the Hot Continental.

In the eastern United States, the Warm Continental Division is synonomous with the Laurentian Mixed Forest Province. This Province occurs between latitudes 40° and 55° North and extends from the continental interior to the east coast. It is made up of the north-central Lake-Swamp-Moranic Plains and the Adirondack-New England Highland landforms. The entire area was glaciated during the Pleistocene and thus lakes, poorly drained depressions, moranic hills, drumlins, eskers, and outwash plains are common. Elevations within the province are generally from sea level to 4,000 feet with a few peaks of above 5,000 feet. Rolling hills of low relief characterizes most of the area, but the mountains of the Adirondack-New England Highlands have reliefs of 1,000 to 3,000 feet. Winters are cold and moderately long and snow cover is usually present all winter. Summers are warm--more than 120 days of temperature above 50°F.--but the growing season is short and the frost-free period is from 100 to 140 days. Precipitation ranges from 24 to 45 inches with a maximum in the summer and no dry seasons (Bailey 1978).

The vegetation of the Province is transitional between the boreal forests to the north and the deciduous forests to the south and is composed of stands of mixed coniferous-deciduous species, or mostly pure deciduous stands on favorable sites, and mostly pure coniferous stands on less favorable sites (Bailey 1978). The pines and many of the deciduous species are pioneers that follow fire or abandonment of cleared land. Four plant association sections are recognized within the province: Spruce-Fir, Northern Hardwoods-Fir, Northern Hardwoods, and Northern Hardwoods-Spruce (figs. 1 and 2).

The Hot Continental Division lies immediately adjacent to the Warm Continental Division. The boundary between the two is the 72°F. warmest-month isotherm. The landforms comprising the Eastern Deciduous Forest Province of this Division are the East-central Drift and Lakebed Flats, the Eastern Interior Uplands and Basins, and the Appalachian Highlands. Only the northern parts of the Province were glaciated. Elevations range from sea level to 2,500 feet with a few peaks above 4,500 feet. Most of the area is rolling and has low relief, but in the Appalachian Highlands relief is as much as 3,000 feet. The climate is one of cool winters and hot summers with 35 to 60 inches of annual precipitation and a maximum in summer. The vegetation is primarily deciduous broadleaf--northern hardwoods or oaks--and conifers at higher elevations. On low, wet areas, the vegetation is primarily bottomland hardwoods and spruce. The plant association sections that make up the Province are the Maple-Basswood and Oak Savanna, Beech-Maple, Mixed Mesophytic, Appalachian Oak, and Oak-Hickory (figs. 1 and 2).

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- DOMAIN (2) HUMID TEMPERATE
  - DIVISION (21) WARM CONTINENTAL
    - PROVINCE (211) LAURENTIAN MIXED FOREST
      - SECTION (2111) Spruce-Fir
      - (2112) Northern Hardwoods-Fir
      - (2113) Northern Hardwoods
      - (2114) Northern Hardwoods-Spruce
  - DIVISION (22) HOT CONTINENTAL
    - PROVINCE (211) EASTERN DECIDUOUS FOREST
      - SECTION (2211) Mixed Mesophytic
      - (2212) Beech-Maple
      - (2213) Maple-Basswood and Oak Savanna
      - **(2214) Appalachian Oak**
      - (2215) Oak-Hickory

Figure 1.--*Ecoregion classification of northeastern United States forests (Bailey 1978)*

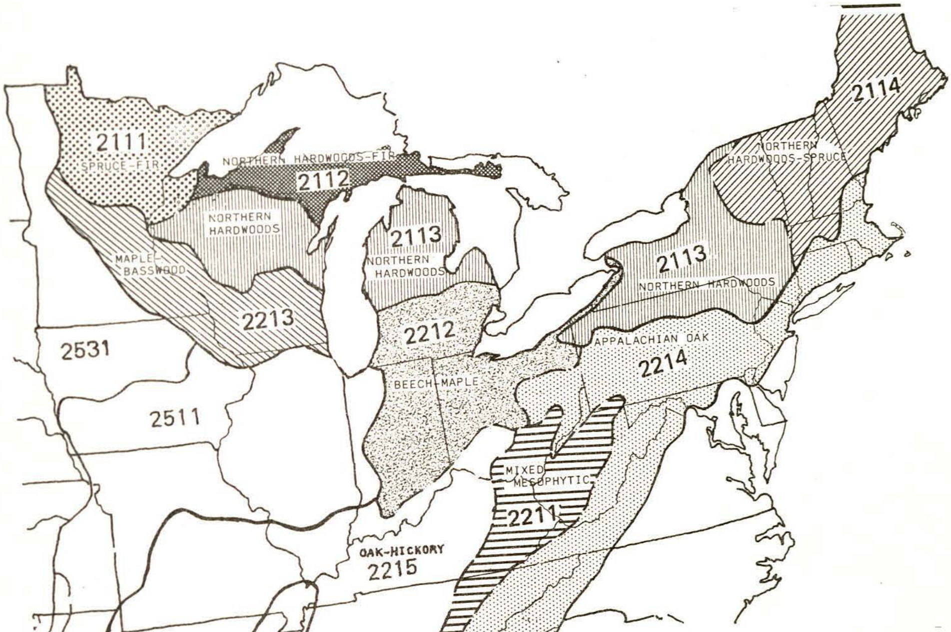
2111
SPRUCE-FIR
NORTHERN HARDWOODS-FIR
2112
NORTHERN HARDWOODS
MAPLE-BASSWOOD
2213
2531
2511
2113
NORTHERN HARDWOODS
2212
BEECH-MAPLE
2114
NORTHERN HARDWOODS-SPRUCE
2113
NORTHERN HARDWOODS
APPALACHIAN OAK
2214
MIXED MESOPHYTIC
2211
OAK-HICKORY
2215

Figure 2.--*Forest types of the north-central and northeastern United States according to Bailey's 1978 Ecoregion classification.*

MANAGEMENT SYSTEMS

Forest land is managed primarily by cover type and the types are based on the majority of trees in the stand. Those typically listed for the north-central region are jack pine, red pine, aspen, northern hardwoods, and black spruce. The principal northeastern types are spruce-fir, eastern white pine, northern hardwoods, cherry-maple, and Appalachian mixed hardwoods. Other types that are important in one or both regions are northern white-cedar, cove hardwoods, oak-pine, and lowland (bottomland) hardwoods.

Many of the forest types in the north-central and northeast are dominated by shade-intolerant species characteristic of early succession, and thus lend themselves best to even-aged silvicultural systems. Under even-aged management the goal is to regenerate and culture stands that are about the same age (all desired trees receive the same amount of direct sunlight during regeneration and growth of the stand). Even-aged management can be a clearcut at rotation age followed by regeneration of the stand through direct seeding, as is common for jack pine; through planting, as is common for red pine; or through allowing resprouting, as is common for aspen. Even-aged management can also include leaving shelterwood or seed trees when harvesting near the end of a rotation to provide natural regeneration, followed by removal of the shelterwood trees or seed trees after the new stand is established.

Even-aged silvicultural practices range from a "let-grow" policy to intensive managemant where both noncommercial and commercial thinnings are made prior to final harvest (Ohmann *et al.*1978). The intensity of management depends on species composition, stand condition, site quality, markets, and management objectives for resources other than wood products.

Forest types composed of tolerant species (sugar maple, beech, spruce, or fir) are often managed under uneven-aged (all-aged) systems. The usual harvest method under this system is to periodically remove selected mature and immature trees either singly or in small groups. Regeneration occurs almost continuously, thus creating an uneven-aged stand of trees of different ages or sizes intermingled either singly or in small groups. The single tree selection method in mixed species stands leads to an increase in the proportion of the more shade-tolerant species in the stand. The group selection method can be used to maintain a higher proportion of less shade-tolerant species.

FOREST TYPES

Presented below are the principal forest cover types of the north-central and northeastern regions, the Ecoregion and Kuchler (1964) plant associations in which they may occur, the typical timber products desired from them, and the usual silvicultural practices used to meet the timber objectives. More detailed information about each type can be found in the management guides from which the data was summarized.

Jack Pine

The jack pine (Benzie 1977a) type occurs primarily in the north-central region where it occupies about 2.5 million acres. It is found in the Spruce-Fir, Northern Hardwoods-Fir, and the Northern Hardwoods Ecoregion Sections (fig. 2) and in Kuchler's Great Lakes Pine Forest type.

Jack pine grows in both pure and mixed stands. Common associates in mixed stands are red and eastern white pine, aspens, white birch, several oaks (mainly northern red oak and northern pin oak), and spruce-balsam fir mixtures. The type is usually found on level to gently rolling sand plains of glacial outwash, fluvial, or lacustrine origin. It also grows on eskers, sand dunes, rock outcrops, ridges, and glacial lake beds and beaches.

Jack pine is a small, short-lived species that establishes readily on recently burned areas, especially on exposed sand sites. It is less shade-tolerant than any of its principal associates except quaking aspen and white birch. Thus, jack pine is a temporary type that on better sites is replaced by more shade-tolerant species when natural succession is not interrupted by fire. On poor sites, jack pine is more permanent and usually grows in pure stands but may be mixed with northern pin oak. The poorest jack pine sites are largely free of shrubs, the medium sites are characterized by ericaceous low shrubs, and the better sites often have a dense undergrowth of tall shrubs.

Jack pine is one of the few species that is generally not re-established where it grows best. Typical timber management objectives are to maintain the type where it is the best-suited species and to replace it at the end of rotation with more productive species (such as red pine) on sites where it is not the best-suited species. Most stands are managed for pulpwood, but stands on the best sites (SI=60+) may be managed for poles or small sawtimber with intermediate thinning.

The preferred silvicultural practice for the type is even-aged management with a regeneration harvest through clearcutting. This is followed by preparing the site through mechanical scarification, chemical control of vegetation, or prescribed burning. Then, the site is planted or seeded (branches bearing serotinous cones are scattered over the area or seeds are dispersed directly on the mineral soil). Jack pine is occasionally regenerated by the seed-tree system if good quality seed trees are available and prescribed burning can be used to prepare the site. Commercial rotation ages are typically 40 to 50 years for pulpwood and on good sites, 60 to 70 years for poles and small sawtimber.

Red Pine

Red pine (Benzie 1977b) occupies about 1 million acres in the north-central region and less than 0.5 million acres in the northeastern region. Although the area of natural red pine forest is small in both regions, it has been greatly expanded by planting. It is found in the Spruce-Fir, Northern Hardwoods-Fir, Northern Hardwoods, and Northern Hardwoods-Spruce Ecoregion Sections (fig. 2) and in Kuchler's Great Lakes Pine Forest type. Naturally occurring red pine is most common on level to gently rolling topography underlain by fine to loamy sands or on low ridges adjacent to lakes and swamps. It grows best on moist, well-drained soils but can withstand moderate drought. In the north-central region, red pine grows in both pure and mixed stands. Associated species on coarse, dry soils are jack pine, aspen, white birch, and northern pin oak. On fine to loamy sands, associates include eastern white pine, red maple, northern red oak, and white spruce-balsam fir mixtures.

Typically, red pine stands are managed intensively to produce pulpwood, posts, poles, cabin logs, and small sawtimber from intermediate thinnings, and high-quality sawtimber and veneer logs from the final crop.

The preferred silivicultural practice is even-aged management with periodic thinnings and a final regeneration harvest through clearcutting. This is followed by preparing the site through mechanical scarification, chemical control of vegetation, or prescribed burning and planting seedlings. Red pine is usually released from competing vegetation by the end of the third growing season. Commercial rotation ages range from 60 years (on best sites with thinning) to 120 years.

White Pine

Eastern white pine (Little *et al.* 1973), the mainstay of the early logging era, is now of minor importance as a timber species in the north-central region. Throughout most of the Lake States, it is threatened by white pine blister rust. Thus, white pine is infrequently planted and planting will not widely increase until rust-resistant stock becomes readily available. Naturally occurring white pine is found in scattered stands throughout the north-central region but is most frequently found as a component of other types--as a super-canopy, as scattered individuals, or as a dominant or codominant component of red pine stands. In the north-central region it occurs in the Spruce-Fir, Northern Hardwoods-Fir, and Northern Hardwoods Ecoregion Sections (fig. 2) and in Kuchler's Great Lakes Pine Forest type. White pine remains an important forest type in the northeastern region where it covers about 7 million acres. It occurs in the Northern Hardwood-Spruce and Appalachian Oak Ecoregion Sections (fig. 2). In the northeast, white pine is often a pioneer species in abandoned fields and pastures. Optimum development is on moist, deep loams or on sandy loams of lower slopes, but it also is able to compete on upper slopes and ridgetops. Common associates of white pine include 9 conifers and at least 18 hardwood species. Densely stocked pure or nearly pure stands of white pine in the north-central region have a poorly developed tall shrub layer, and a low shrub layer that is more prominant than the sparse herbaceous ground cover.

White pine is not well suited for pulpwood, so sawtimber is the major timber management objective (other than Christmas trees). Small wood products can be derived from thinnings, tops, and limbs.

The preferred silvicultural practice is even-aged management with an intermediate thinning and a regeneration harvest through clearcutting followed by site preparation and planting. If a final heavy thinning is made during a good seed year about 10 years prior to clearcutting, good natural regeneration can be expected and advanced regeneration will be available at the final harvest. Release from competing vegetation will usually be necessary. The white pine type is also often harvested and regenerated through a two-stage shelterwood system. Commercial rotation age is from 80 to 120 years.

Spruce-fir

The spruce-fir (Gibbs 1973) type occupies nearly 3 million acres in the north-central region and occurs in the Spruce-Fir, Northern Hardwoods-Fir Ecoregion Sections (fig. 2) and in Kuchler's Great Lakes Spruce-Fir Forest type. In the Lake States, balsam fir is typically more abundant within the type than is white spruce. Spruce-fir is considered the climax forest type for a major part of the Lake States occupied by aspen, birch, and associated conifer forests (Ohmann and Ream 1971). In the north-central region, old-growth stands have various mixtures of balsam fir, white birch, and white spruce. These stands may also contain some black spruce, aspen, and northern white-cedar, and a few black ash, red maple, and balsam poplar. If succession is less advanced, white, red, and jack pine may also by associated with the type. Sometimes, small (usually less than 10 acres), scattered stands of pure fir will originate after fire, windstorms, or epidemics of spruce budworm.

In the Lake States balsam fir occurs also as an understory strata within stands of aspen, white birch, jack pine, white pine, and occasionally red pine. In the natural course of succession, these areas will become spruce-fir. Much of the spruce-fir type within the north-central region originated in this manner, particularly on areas that were undisturbed for many years. North-central region spruce-fir stands typically have a well-developed tall shrub layer, a poorly developed low shrub layer, and a ground cover of mosses that predominate over herbs.

The northeastern region spruce-fir type occurs in the Northern Hardwoods-Spruce Ecoregion Sections(fig. 2) and in Kuchler's Northeastern Spruce-Fir Forest type. Red spruce, white spruce, and balsam fir are the principal species in this region. The type covers nearly 11 million acres in New England and New York. Depending on site conditions, stands may contain only the spruces and fir or spruce-fir in various combinations with other conifers and hardwoods. These other conifers include northern white-cedar, eastern hemlock, eastern white pine, and tamarack. The hardwoods include red maple, paper birch, aspen, white ash, American beech, sugar maple, and yellow birch. Red spruce, white spruce, and balsam fir will grow on a variety of soils, including those that are poorly drained.

In both the Lake States and New England regions, the typical timber objective is to manage the better sites for balsam fir pulpwood and white or red spruce sawtimber. In the central Appalachians, red spruce on good sites is managed for large sawtimber and on poor sites is either managed for pulpwood or reserved for recreation and aesthetic purposes.

The preferred silvicultural practice is even-aged management with regeneration harvest by clearcutting narrow strips or small patches so adjacent areas can shade advance regeneration or serve as a seed source if advance regeneration is not present at harvest. Commercial rotation age is about 70 years for pulpwood and 120 to 150 years for sawtimber. Uneven-aged management can be used in all-aged stands or to achieve an all-aged structure. In these cases, selection cutting of single trees or small groups of trees is done every 5 to 20 years.

Black Spruce

The black spruce (Johnston 1977a) forest type occupies about 2.1 million acres in the north-central region. Sixty-eight percent of this acreage is in Minnesota, and the remainder is in the northern parts of Michigan and Wisconsin. The black spruce type is a major source of pulpwood in northern Minnesota. Christmas trees are harvested on a limited scale on sites too poor for growing pulpwood. The type also occurs as scattered stands on low areas within the northeastern region. Black spruce occurs in the Spruce-Fir, Northern Hardwoods-Fir, Northern Hardwoods-Spruce Ecoregion Sections (fig. 2) and in Kuchler's Conifer Bog Forest type.

Black spruce grows in both pure and mixed stands; in some mixed stands it predominates and in others it is important but not predominant--mixed swamp conifer, upland white spruce-balsam fir, and jack pine types.

The black spruce type is found on organic soil in both regions and on mineral soil in the Lake States. Extensive areas of organic soil are found on gently sloping glacial lakebeds or smaller filled lakes associated with the Laurentian Shield, pitted outwash plains, and morainic areas. On both lakebed and filled-lake sites, the growth rate of black spruce is related to the surrounding ground water flow system. The best sites occur where the soil water is continuous with the regional ground water system and thus is enriched with nutrients flowing from mineral soil areas. The poorest sites occur where the soil water is "perched" above and therefore separated from this regional system. The fertility of these latter sites depends mainly on precipitation, which is low in nutrients.

The black spruce type is common on mineral soil only on the Laurentian Shield area of northeastern Minnesota and in a few isolated areas of Upper Michigan. In these areas black spruce grows on gravelly and bouldery loam and on shallow soil over bedrock. It is usually mixed with other species--jack pine, aspen, and balsam fir--but occasionally forms a pure type. Growth is best where the slope is gentle and moisture is plentiful, either from a shallow water table or seepage. South of the Shield, black spruce is occasionally found on sandy soil with a high water table.

Black spruce stands on the best organic soil sites typically have a dense understory of tall shrubs and stands on medium to poor sites have only a few low shrubs and many sphagnum and feather mosses. Pure black spruce stands on mineral soils often have a poorly developed shrub and herb component and an extremely well-developed carpet of moss (Ohmann and Ream 1971).

The typical timber objective for the type is to manage for a sustained yield of pulpwood on good sites (SI >25) and for Christmas trees on poor sites.

The preferred silvicultural practice is even-aged management with a regeneration harvest through clearcutting, followed by broadcast burning to prepare the site for seeding. Cut strips up to 4 chains wide can be naturally seeded but large patches must be direct seeded. Burning of slash is recommended for all brushy sites, sites with heavy slash, and sites containing dwarf mistletoe. Release from competing shrubs and hardwoods on good sites is usually necessary. Commercial rotation age is from 60 to 160 years depending on stand basal area and stem density. On poor sites, Christmas trees can be grown under uneven-aged management with group selection cutting about every 10 years.

Northern White-cedar

The white-cedar (Johnston 1977b) type occurs in both the north-central and northeastern regions and is found in the Spruce-Fir, Northern Hardwoods-Fir, Northern Hardwoods, and Northern Hardwoods-Spruce Ecoregion Sections (fig. 2) and in Kuchler's Conifer Bog Forest type. The type is most common in the north-central region. It occupies 1.9 million acres in the Lake States, most of it (62 percent of the acreage) in Michigan. The remainder occurs in the northern parts of Minnesota and Wisconsin.

Northern white-cedar grows in both pure and mixed stands. In some mixed stands it predominates and in others it is important but not predominant, such as in the mixed swamp conifer, black spruce, tamarack, and black ash-American elm-red maple types.

The northern white-cedar type is found primarily on organic soils in the Lake States, but is also occurs on mineral soils, mainly on seepage areas and limestone uplands.

Organic soil origin, degree of decomposition, and drainage in the upper horizons are good guides to site productivity. The best soils are neutral or slightly alkaline and contain moderately-to well-decomposed organic matter derived from woody plants or sedges. However, the upper 4 inches on these sites may be poorly decomposed sphagnum or other mosses. The best sites have moving soil water and are usually near streams or other drainageways. In contrast, the poorest sites have poorly decomposed acid soil, derived from plants such as sphagnum moss, throughout the entire root zone. These sites have little water movement and are often far from drainageways.

Typically, the tall shrub layer is well-developed, and the species composition varies depending on whether the stand is on organic or mineral soil. The low shrub layer and the herb layer are usually poorly developed. Mosses predominate over herbs in the latter, especially on organic soil.

The typical timber management objective is a sustained yield of posts, poles, and sawtimber. Sites less than SI=25 should be managed extensively for small posts.

The preferred silvicultural practic is even-aged management with regeneration harvest through clearcutting narrow strips or small patches and relying on natural seeding (large clearcut patches will require direct seeding). A combination of clearcut and shelterwood (alternate or progressive strips) can also be used. Broadcast burning of slash, except where shelterwood trees are present or where residual stems are to be saved, will help ensure regeneration. Commercial rotation age varies with site and management objective: 100 to 140 years on poor sites; 70 to 90 years for posts on good sites; and 110 to 140 years for sawtimber on good sites.

Aspen

Aspen (Perala 1977) covers about 13 million acres and is the largest and most widely distributed of the forest types in the north-central region. The type also occurs in the northeastern region. It can be found within the Spruce-Fir, Northern Hardwoods-Fir, Northern Hardwoods, and Northern Hardwoods-Spruce Ecoregion Sections (fig. 2) and in Kuchler's Great Lakes Pine Forest, Great Lakes Spruce-Fir Forest, Northeastern Spruce-Fir Forest, and the Northern Hardwoods Forest types. The dominant species is quaking aspen, which is a small to medium-sized tree that can grow in essentially pure stands but usually is found with other species. Common associates are bigtooth aspen, white birch, northern red oak, red maple, balsam poplar, jack pine, balsam fir, spruce, and northern white-cedar.

Aspen occupies diverse soils and sites, and its growth rate varies with soil fertility and available moisture. Aspen has persisted in natural stands largely because of fire. Even where it is a minor component of the stand, aspen's ability to produce abundant root suckers often enables it to become the dominant species after logging or fire. If aspen is already dominant, it easily re-establishes itself after logging, especially when cutting is followed by fire or similar treatments to kill back all vegetation.

Because aspen cannot reproduce successfully under its own shade, it is replaced by other species when natural ecological succession is not interrupted by fires, logging, or windstorms. On dry sites, aspen is succeeded by red maple or oaks. On moist, fertile soils, aspen is followed by balsam fir, white or red spruce, white pine, or northern hardwoods. On wet sites aspen is succeeded by balsam fir, black spruce, or northern white-cedar.

Aspen stands typically contain well-developed shrub and herb layers. Plant species diversity is usually greater in this type than in any of its associated conifer forest types.

Timber management objectives vary with site. For most stands the objective is pulpwood. Good sites (SI>80) can be managed to produce veneer bolts and sawtimber. Poor sites (SI<50) can produce fiber through whole-tree utilization and chipping but can be converted to conifers or other hardwoods at the end of the rotation.

The preferred silvicultural practice is even-aged management with a regeneration harvest through clearcutting followed by natural vegetative sprouting. Clearcuts should be larger than 2 acres. Aspen stands with a northern hardwood understory can be regenerated by clearcutting or can be converted to northern hardwoods by using the shelterwood or selection cutting systems. Commercial rotation age is 35 to 45 years for chipping or pulpwood and 50 to 60 years for veneer bolts and sawtimber.

Northern Hardwoods

The northern hardwood (Tubbs 1977, Filip and Leak 1973) forests cover about 10 million acres in the north-central region and about 15 million acres in the northeastern region. The type can be found in the Northern Hardwoods-Fir, Northern Hardwoods, Northern Hardwoods-Spruce, Maple-Basswood, and Beech-Maple Ecoregion Sections (fig. 2) and in Kuchler's Maple-Basswood, Northern Hardwoods, Northern Hardwood-Fir, and Beech-Maple forest types. The type varies in composition and density depending on soil drainage, past cutting practices, and fire. Characteristic species are sugar maple, American beech, yellow birch, and eastern hemlock. In places basswood, paper birch, white ash, red maple, American elm, and eastern white pine are important associates. On well-drained upland loamy soils in the north-central region, sugar maple is the dominant species and beech, yellow birch, or basswood are the codominant species. On poorly drained sites, hemlock and yellow birch are dominant in the type.

In the northeastern region northern hardwood forests are found up to elevations of about 2,000 feet on rolling or mountainous land. The most productive soils are deep and well- to moderately-well drained.

Typical timber objectives are to manage for high-quality veneer and saw logs where species composition, age distribution, and site productivity allow. Other, less suitable stands are usually managed for pulpwood.

If the objective is to promote composition and yield of the more valuable, less tolerant species (primarily birches), the preferred silvicultural practice is even-aged management with a regeneration harvest through some form of clearcutting and site preparation or a shelterwood cut combined with site scarification and removal of undesirable advanced regeneration. Commercial rotation ranges from 50 to 120 years depending on site, management objective, and intensity of management. If the objective is to promote tolerant species (sugar maple, beech, hemlock, and spruce), uneven-aged management is used with regeneration of the type through selection cutting of individual trees or small groups. Adequate advanced regeneration is almost always present. Periodic cutting will increase composition and yield of desirable trees. Cutting cycles should be about 8 to 12 years in the Lake States and 10 to 20 years in the Northeast.

Cherry-maple

The cherry-maple (Marquis 1973) or Allegheny hardwood type covers about 12 million acres and is a pioneer forest type found within the northeastern region on the Allegheny Plateau of Pennsylvania and New York. It occurs in the Mixed Mesophytic and Beech-Maple Ecoregion Sections (fig. 2) and in Kuchler's Mixed Mesophytic Forest type. It owes its origin to the lumbering and fires of the 1890 to 1920 era in the vast hemlock-white pine-northern hardwoods region of the eastern deciduous forest.

The type is composed primarily of black cherry, red maple, and sugar maple, and common associates are white ash, yellow and sweet birch, American beech, and eastern hemlock. Within this type, black cherry is by far the most valuable species for timber production. Although black cherry grows over a wide geographic area in the eastern United States, it is much more abundant in the Allegheny hardwood area than elsewhere. Ash and maple are two other important timber species of this type.

Because the type occurs on fair to excellent sites, the typical timber objective is to manage for saw and veneer logs. The better the site, the more intensive the management that is economically feasible. On some fair sites, small wood products are the most typical objective (Trimble *et al.* 1974).

When the opportunity exists to manage for the more valuable black cherry and white ash, the preferred silvicultural practice is even-aged management with intermediate thinning at about 30 years and a final regeneratio harvest through clearcutting. Commercial rotation age is between 60 and 135 years. When the opportunity for cherry and ash are poor and sugar maple is the best alternative, uneven-aged management with selection cutting of individual trees or small groups of trees is recommended because sufficient advanced maple regeneration is almost always present.

Cove Hardwoods

The cove hardwoods (Trimble 1973), also known as the Appalachian mixed hardwoods, is the most productive hardwood type of the northeastern region. It occurs in the Mixed Mesophytic Ecoregion Section (fig. 2) and in Kuchler's Mixed Mesophytic Forest type. The type is found in the coves and on the moist slopes of the central and southern Appalachian Mountains and adjacent portions of the Allegheny and Cumberland Plateaus.

Cove hardwoods are highly productive and usually occupy good to excellent sites. Soils on these sites are normally deep, medium textured, and well drained and annual precipitation is ample and well-distributed throughout the year. On these rich sites, major species are long lived and can grow to very large sizes.

Stands are characterized by a great diversity of dominant and subdominant species. The species and their proportions vary considerably because of differing past treatments or natural disturbances on sites of different quality, aspect, elevation, and latitude. Species composition ranges from almost pure northern red oak to pure yellow-poplar but generally is a mixture that contains 20 or more commercial species. Important components are yellow-poplar, northern red oak, sugar and red maples, white oak, American beech, white ash, American basswood, black cherry, cucumbertree, sweet and yellow birches, hickories, yellow buckeye, and black locust. Many other species occur occasionally, including a few conifers--eastern white pine, red spruce, and eastern hemlock. On good sites at high elevations, the type merges with northern hardwood-black cherry mixtures. On dry sites with shallow soils, the type gives way to oak-hickory.

Because the type grows on the best sites and is the most profitable timber type in the northeast, management objectives are high-quality veneer and saw logs, and small wood products from thinnings, tops, and limbs.

The preferred silvicultural practice is even-aged management with intermediate thinnings and a final regeneration harvest through clearcutting to produce the most desirable mix of species in the new stand. Regeneration for the new stand comes from (1) sprouting from cut trees, (2) advanced regeneration of tolerant and intermediately-tolerant species, and (3) germinating seed, which was stored in the forest floor, from the intolerant yellow-poplar and black cherry. Final harvest rotation may be as short as 60 to 70 years with a heavy thinning schedule and control of tolerant understory at harvest. More typical rotations are from 75 to 105 years. Uneven-aged management through selection cutting of small groups of trees is possible but less desirable because it results in an increase of the less valuable maple and beech.

Oak-Pine

The oak-pine (Trimble *et al.* 1974) type occurs in the northeastern region as part of the Appalachian mixed hardwoods forest at elevations below 3,000 feet. It is found within the Appalachian Oak Ecoregion Section (fig. 2) and in Kuchler's Appalachian Oak Forest type. The five widely-distributed upland oaks in this type are white, northern red, black, scarlet, and chestnut. Although less abundant, the hickories are consistent stand components. Other associates are beech, red maple, sassafras, and sweet birch. Oaks are associated with white pine and pitch pine in parts of the region and with the hard pines in the western and southern parts of the central Appalachians. Oak stands commonly have a poorly developed herb layer and a well-developed shrub/vine strata.

On fair oak sites, management is typically for saw logs (sometimes pulpwood), and small wood products from thinnings, tops, and limbs. On poor oak sites (SI=45 to 54) pulpwood is the usual objective but these sites should probably be converted to pine at the end of the rotation. The management objective for pine is to grow it in pure stands for pulpwood.

The preferred silvicultural practice on fair oak sites is even-aged management with intermediate thinning at 30 to 40 years and a final regeneration harvest through clearcutting if advanced oak regeneration is present. Regeneration of the stand through shelterwood cutting is recommended if no oak advanced regeneration is present. Commercial rotation age may be 70+ years. Uneven-aged management is possible through selection harvest of groups of trees. On poor oak sites either even-aged management with regeneration harvest through clearcutting or converting to pine is recommended. Pulpwood rotation on poor sites is 40 to 60 years. The usual practice for pine is even-aged management with a regeneration harvest through clearcutting. Then, the site is prepared, pine is planted, and in several years the trees are released from competing vegetation regrowth. Commercial rotation age for pine is 40 to 50 years.

Lowland Hardwoods

The lowland hardwoods (Trimble *et al.* 1974) type is also known as the bottomland hardwoods, flood plain hardwoods, or swamp hardwoods. It occurs throughout both regions and varies mostly with the type of landscape on which it occurs. It can be found in all Ecoregion Sections and in Kuchler's Elm-Ash or Northern Flood Plain Forest type. It includes American elm, black willow, green ash, red maple, silver maple, boxelder, and several oak species.

On good sites sawtimber is the usual timber objective and on poor or wet sites pulpwood is the usual objective.

The preferred silvicultural practice is usually even-aged management with regeneration of the type through clearcutting followed by early precommercial treatment to remove undesirable competing shrubs and trees. If pockets of hemlock are present, they can be maintained by a shelterwood harvest with ground scarification. Poor or wet sites, if not converted to spruce, can be regenerated by using the shelterwood system. On good sites in the northern parts of the Lake States, uneven-aged management is recommended with selection harvest of individual trees to prevent shrubs and grasses from invading the site.

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Tuesday Afternoon, January 23

NONGAME BIRD HABITAT MANAGEMENT

Moderator: Roger Holmes
Minnesota Department of
Natural Resources

THE EFFECTS OF CHANGES IN HABITAT ON NORTHERN HARDWOOD FOREST BIRD COMMUNITIES

Barry R. Noon[1], Verner P. Bingman[2], and J. Paige Noon[3]

Abstract.--The effects of habitat change on the avian communities of northern hardwood forests were examined from several perspectives. First, we critically reviewed published reports dealing specifically with the response of birds to habitat change. We then examined bird census data from communities representing varying degrees of habitat disturbance. Specifically, we analyzed census data according to the shape of their rank-abundance distributions and drew inferences about their community structure according to their fit to known distributions.

The consensus of the published accounts that we reviewed is that, over the long term, bird communities are very resilient to habitat change. We generally concur with these findings but with notable exceptions. Most importantly we found that the rare species of undisturbed forests are particularly sensitive to habitat changes. In many disturbed habitats the rare species group is either greatly reduced or completely eliminated. From a conservation perspective, we feel that the normally rare species of undisturbed forests should be of primary concern to forest managers in order to assure their persistence.

INTRODUCTION

It is generally accepted that habitat selection by passerine bird species is most strongly influenced by the structure of the vegetation (MacArthur and MacArthur, 1961; MacArthur et al., 1966; Cody, 1968; Wiens, 1969; James, 1971; Shugart and Patten, 1972; Anderson and Shugart, 1974; Whitmore, 1977; and others). Further, niche separation by specific habitat selection appears to be the most common mechanism of achieving competitive coexistence in temperate bird communities (e.g., Shugart and Patten, 1972; James, 1971; Whitmore, 1977; Noon and Able, 1978; Noon, 1979). In light of the apparent integral connection between habitat structure and species composition, it becomes very important to assess the impact of habitat disturbance on avian communities.

From the studies references above one would predict that habitat alterations, such logging, would result in dramatic changes in bird species composition. However a search of the literature quickly reveals little quantitative information documenting the effects of habitat change on the populations of passerine birds. Hagar's (1960) studies of Douglas-fir forests revealed that logging altered the composition of the bird community and caused a short term decline in the density of breeding birds. Density rapidly returned to pre-cut levels, but the species composition remained changed for many years.

Kilgore (1971) studied the effect on bird species of a large scale reduction in the understory of a giant sequoia forest. He reported only slight changes in species composition, with ground-foraging and ground-nesting birds decreasing and flycatchers and robins increasing. Bird density increased on the disturbed site, however, total breeding bird biomass remained constant.

Hooper (1967, unpublished master's thesis; cited in Webb, et al., 1977) studied clearcut stands in Virginia 6 years after logging. He reported both an increase in species richness and density which he attributed to increased understory development. Conner et al. (1975) studied the effect of clearcutting on the populations of 4 woodpecker species in Virginia. In the absence of snags they found this level of logging benefited only one of the 4 species, with the other 3 restricted to less disturbed forests.

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Recently, the results of a long-term investigation into the effects of logging on songbird populations in a northern hardwood forest have been reported (Webb *et al.*, 1977). Due to the direct relevance of their research to this symposium, we will discuss the results of their monograph in some detail. In addition, we examine many breeding bird censuses collected from both mature and disturbed hardwood forest communities in order to gain further insights into the apparent correlation between habitat structure and species composition. We conclude by attempting to identify those species groups most negatively affected by habitat disturbance and thus in most immediate need of effective habitat management.

DESCRIPTION OF FOREST TYPE

Northern hardwood forest communities have an ecotonal character, lying south of the pure coniferous forest of the Canadian zone and north of the pure deciduous forest of more austral regions. However, they are not just transitional subclimax forests, but rather represent an extensive climax forest type. Their character alternates between pure deciduous, mixed, and coniferous regions. In the primary deciduous communities the dominant tree species are sugar maple, beech, basswood, yellow birch and red maple. In secondary deciduous communities, aspen, balsam poplar, paper birch, and gray birch are abundant species (Braun, 1950). In northern Michigan and Minnesota the aspen-birch association is the dominant secondary forest type.

The region contains four groups of species (Braun 1950; (after Nichols 1935)): 1) those with distinct southern affinities - beech, white ash, black cherry; 2) those whose northern limit occurs in the northern hardwood zone - sugar maple, basswood and northern red oak; 3) those species which reach their maximal abundance within the northern hardwood forest region - hemlock, white pine, yellow birch and red spruce; and 4) those whose centers of north-south distribution lie within the Canadian zone - white and black spruce, fir, larch, balsam poplar, and paper birch.

The primary mixed communities in north central and northeastern regions are mixtures of northern hardwoods and hemlock. In montane regions of the northeast the primary hardwoods, sugar maple, beech and yellow birch, are mixed with red spruce and in virgin areas with large white pines. In the northeastern zone of the hardwood forest belt the term hemlock-hardwood forest is most applicable. However, in western regions of this zone hemlock is absent and white pine becomes a regular climax dominant (Braun, 1950). In the extreme northern limits of this zone white spruce and balsam fir also achieve dominant status.

Along steep moisture gradients the composition of northern hardwood communities often change rapidly (Fig. 1) giving many areas a mosaic appearance. This pattern greatly increases local bird species diversity. The discrete forest types integrate abruptly into one another and are frequently large enough to maintain regular populations of habitat specialist bird species. This large scale patchiness, particularly pronounced in northeastern hardwood forests, contributes extensively to the high species richness characteristic of these latitudes.

The northern hardwood forest region extends from northern Minnesota and southeastern Manitoba eastward through the upper Great Lake regions, across New England and north to southern Canada (Braun, 1950). It covers most of the Appalachian Plateau in New York and Pennsylvania and has an extensive finger-like projection down the

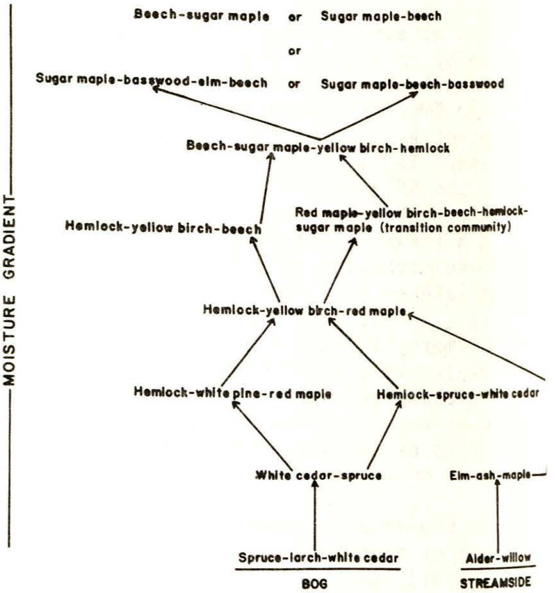

Beech-sugar maple or Sugar maple-beech
or
Sugar maple-basswood-elm-beech or Sugar maple-beech-basswood
Beech-sugar maple-yellow birch-hemlock
Hemlock-yellow birch-beech
Red maple-yellow birch-beech-hemlock-sugar maple (transition community)
Hemlock-yellow birch-red maple
Hemlock-white pine-red maple
Hemlock-spruce-white cedar
White cedar-spruce
Elm-ash-maple
Spruce-larch-white cedar
BOG
Alder-willow
STREAMSIDE
MOISTURE GRADIENT

Figure 1.--Relationship of various forest communities of the northern hardwood region arrayed along a gradient of decreasing water requirements from bog to elevated ridge (after Braun, 1950).

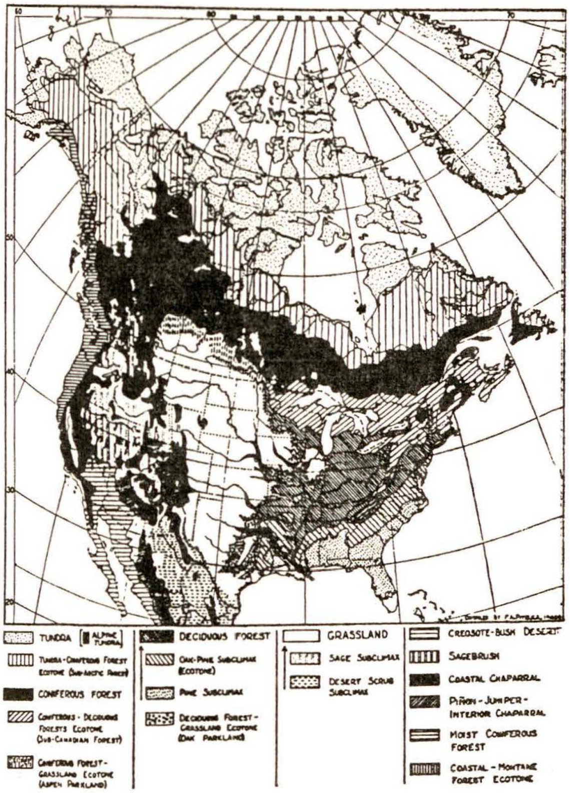
Appalachian Mountain chain into western Maryland and West Virginia. The cross-hatched region of Figure 2, labeled coniferous-deciduous forest ecotone, indicates the extent of this forest type.

THE AVIFAUNA

The reader is referred to Table I for a listing of all the species we encountered in our survey of 70 breeding bird censuses. The species tabulated are found breeding in either mature and/or disturbed habitats. Of particular relevance to the topic of our paper are those species which reach their highest frequencies in mature forests, those restricted to these habitats, and those most often encountered as community dominants.

SYNOPSIS OF THE WEBB MONOGRAPH

Webb et al. (1977) studied the long term effects of different intensities of logging on breeding bird populations. Their study area was within a continuous 15,000 acre northern hardwood forest located in New York's Adirondack Mountains. The canopy of this forest was dominated by sugar maple, yellow birch, and beech with hemlock and red spruce comprising a small, but significant component of the forest.



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TUNDRA
ALPINE TUNDRA
TUNDRA-CONIFEROUS FOREST ECOTONE (SUB-ARCTIC FOREST)
CONIFEROUS FOREST
CONIFEROUS-DECIDUOUS FORESTS ECOTONE (SUB-CANADIAN FOREST)
CONIFEROUS FOREST-GRASSLAND ECOTONE (ASPEN PARKLAND)
DECIDUOUS FOREST
OAK-PINE SUBCLIMAX (ECOTONE)
PINE SUBCLIMAX
DECIDUOUS FOREST-GRASSLAND ECOTONE (OAK PARKLAND)
GRASSLAND
SAGE SUBCLIMAX
DESERT SCRUB SUBCLIMAX
CREOSOTE-BUSH DESERT
SAGEBRUSH
COASTAL CHAPARRAL
PIÑON-JUNIPER-INTERIOR CHAPARRAL
MOIST CONIFEROUS FOREST
COASTAL-MONTANE FOREST ECOTONE

Figure 2.--The biomes of North America, with extensive ecotones and certain subregions indicated (after Pitelda, 1941).

Five extensive study sites were selected and subject to 5 levels of treatment. A natural area where no logging was done served as a control. Four areas were logged at 4 different intensities and were identified as the 25, 50, 75, and 100 percent areas. These percentages indicate the approximate amount of commercial timber volume removed when they were first logged. For softwoods the lower dbh limit was 12 inches while for hardwoods the lower limit varied from 14-16 inches dbh. Adirondack forests are particularly well stocked with trees greater than 12 inches dbh (Webb et al., 1977; Noon, unpublished data) and even selective logging results in significant changes in forest structure. The extensive disturbance of at least the 75 and 100 percents areas are still noticeable today (Richard Sage, Jr., personal communication).

Each study site contained 6 censusing stations where every bird seen or heard during a given period of time was tallied. The bird populations on each of the study sites were censused over a 10 year period. Neither the breeding status of individual birds nor the area sampled were determined; thus, only indices of relative abundance of presumed breeders were derived. The sum of the highest number of individuals recorded for a given species at each sampling station became the annual population index for that species for that particular stand. Each species' annual indices were then summer over the 10 annual censuses resulting in a total population index for each species for each stand.

During the 10 year interval a total of 56 species were **recorded**. However, only those species with a cumulative population index of 50 or above were studied for population trends. This reduced the number of species examined to 26 and excluded, for example, all the woodpeckers, except the yellow-bellied sapsucker, and all birds of prey.

The results of Webb et al. (1977) can be succinctly summarized by noting the effects of logging on:

a) Faunal composition: The fauna on the unlogged area was not supplanted by a different fauna on the logged area. Of the 26 "indicator species" only the veery was never observed on the unlogged control. By contrast, 6 species, ruffed grouse, pileated woodpecker, olive-sided flycatcher, veery, mourning warbler, and chipping sparrow were only recorded on logged sites. Using Spearman rank correlation as an index of shifts in importance value, no significant differences in rank order were observed when each of the treatment stands were compared to the control area. However, a trend of decreasing correlation from lightest to heaviest logging was apparent.

Table 1. Avifauna of the northern hardwood forest region.

	Mature (undisturbed) habitats		Disturbed and successional habitats		
Species (by foraging guild)	Percent of censuses recorded	Percent of censuses dominant	Percent of censuses recorded	Percent of censuses dominant	Changes in species frequency
Foliage gleaners					
Yellow-billed Cuckoo	20		3		
Black-billed Cuckoo	5		20		
Blue Jay	53		43		
House Wren	13		17		
Winter Wren	15		7		
Carolina Wren	15		16		
Catbird	10		32		I[b]
Blue-gray Gnatcatcher	3		13		
Cedar Waxwing	3		27		I
Solitary Vireo	8		13		
White-eyed Vireo	-		7		
Yellow-throated Vireo	43		3		D
Red-eyed Vireo	100	67.5	90	20.0	
Philadelphia Vireo	5		-		
Warbling Vireo	-		13		
Worm-eating Warbler	3		3		
Golden-winged Warbler	-		10		
Nashville Warbler	3		30		I
Yellow Warbler	-		13	6.7	
Magnolia Warbler	5		37		I
Yellow-rumped Warbler	5		10		
Black-throated Green Warbler	55	5.0	40	3.3	
Black-throated Blue Warbler	15		40		I
Cerulean Warbler	48		-		
Chestnut-sided Warbler	10		67	16.7	I
Bay-breasted Warbler	5		-		
Pine Warbler	-		3		
Prairie Warbler	-		10		
Palm Warbler	-		3		
Yellowthroat	8		47	16.7	I
Yellow-breasted Chat	3		17		
Mourning Warbler	8		40		I
Hooded Warbler	40		13		D
Canada Warbler	3		27		I
Red-winged Blackbird	-		20		I
Common Grackle	15		17		
Northern Oriole	3		23		I
Scarlet Tanager	78		43		D
Cardinal	70		20		D
Rose-breasted Grosbeak	45		57		
Indigo Bunting	15		47	10.0	I
Purple Finch	3		10		
American Goldfinch	8		13		
Chipping Sparrow	-		23		I
Field Sparrow	20		17		
Swamp Sparrow	-		3		
Song Sparrow	20		43	6.7	I
Average importance of guild (mean and (standard deviation))	.426 (.088)		.528***[a] (.083)		

Table 1. Avifauna of the northern hardwood forest region. (continued)

	Mature (undisturbed) habitats		Disturbed and successional habitats		
Species (by foraging guild)	Percent of censuses recorded	Percent of censuses dominant	Percent of censuses recorded	Percent of censuses dominant	Changes in species frequency
Ground foragers					
Ruffed Grouse	28		27		
American Woodcock	-		7		
Mourning Dove	15		3		
Yellow-shafted Flicker	45		43		
Common Crow	30		7		D
Brown Thrasher	3		13		
Robin	58		50		
Wood Thrush	80		47		D
Hermit Thrush	13		23		
Swainson's Thrush	15		20		
Veery	18		77	10.0	I
Starling	18		10		
Ovenbird	88	7.5	77	10.0	
Northern Waterthrush	-		3		
Louisiana Waterthrush	35		3		D
Kentucky Warbler	10		10		
Brown-headed Cowbird	65		17		D
Rufous-sided Towhee	58		70	3.3	
Dark-eyed Junco	10		37		I
White-throated Sparrow	8		23		
Average importance of guild (mean and (standard deviation))	.287 (.052)		.352* (.088)		
Salliers					
Eastern Kingbird	5		17		
Great-crested Flycatcher	83		23		D
Eastern Phoebe	43		3		D
Acadian Flycatcher	63	10.0	3		D
Least Flycatcher	20	7.5	23		
Alder Flycatcher	-		13		
Eastern Wood Pewee	93		47		D
Olive-sided Flycatcher	-		7		
Eastern Bluebird	3		3		
American Redstart	60	2.5	20		D
Average importance of guild (mean and (standard deviation))	.155 (.098)		.056**** (.063)		
Bark gleaners					
Black-capped Chickadee	65		57		
Carolina Chickadee	25		3		D
Tufted Titmouse	75		3		D
White-breasted Nuthatch	90		17		D
Red-breasted Nuthatch	3		13		
Brown Creeper	5		7		
Black-and-white Warbler	15		57		I
Average importance of guild (mean and (standard deviation))	.054 (.039)		.039 (.029)		

Table 1. Avifauna of the northern hardwood forest region.

	Mature (undisturbed) habitats		Disturbed and successional habitats		
Species (by foraging guild)	Percent of censuses recorded	Percent of censuses dominant	Percent of censuses recorded	Percent of censuses dominant	Changes in species frequency
Predators					
Cooper's Hawk	8		-		
Marsh Hawk	3		-		
Red-tailed Hawk	15		-		
Red-shouldered Hawk	-		3		
Broad-winged Hawk	13		7		
Screech Owl	10		-		
Great Horned Owl	10		-		
Barred Owl	20		3		
Average importance of guild (mean and (standard deviation))	.006 (.006)		.002* (.005)		
Bark drillers					
Pileated Woodpecker	30		17		
Red-bellied Woodpecker	53		-		D
Red-headed Woodpecker	23		-		D
Yellow-bellied Sapsucker	13		17		
Hairy Woodpecker	95		43		D
Downy Woodpecker	83		27		D
Average importance of guild (mean and (standard deviation))	.052 (.041)		.012**** (.016)		
Hover gleaners					
Golden-crowned Kinglet	3		-		
Parula Warbler	10		3		
Blackburnian Warbler	15		13		
Average importance of guild (mean and (standard deviation))	.015 (.020)		.004* (.012)		
Hawkers					
Whip-poor-will	-		3		
Chimney Swift	-		10		
Tree Swallow	-		10		
Average importance of guild (mean and (standard deviation))	- -		.004 (.010)		
	N = 40		N = 30		

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[a] *, $p<.05$; **, $.01<p<.05$; ***, $.005<p<.01$; ****, $p<.001$

[b] I - species frequency increased by at least 20%;
D - species frequency decreased by at least 20%.

b) Diversity: Species richness was lowest on the natural area and increased with logging intensity. However, only at the 2 highest logging intensities was the difference significant. Comparison of the logged stands to the control by their Shannon indices revealed a significant difference only for the 2 highest logging intensities. In both instances these stands had higher diversities, primarily a consequence of the difference in species richness and not evenness. Only the most heavily logged area had a significantly higher evenness.

c) Population trends: Five species showed a negative trend in population size with an increase in logging: ovenbird, black-throated-green warbler, blackburnian warbler, winter wren, and least flycatcher (Fig. 3). The wood thrush had a high population density on the control plot and appeared to be rather equally affected by all levels of logging (Fig. 3). In addition, the yellow-bellied sapsucker responded negatively only to the most intense level of logging. Six species showed a positive trend in population in response to logging: American redstart, chestnut-sided warbler, rose-breasted grosbeak, white-throated sparrow, black-and-white warbler and veery (Fig. 4). Many of the species affected by logging showed trends back towards their pre-treatment levels. Most notable were positive trends for the ovenbird, winter wren and wood thrush and negative trends for the chestnut-sided warbler and white-throated sparrow.

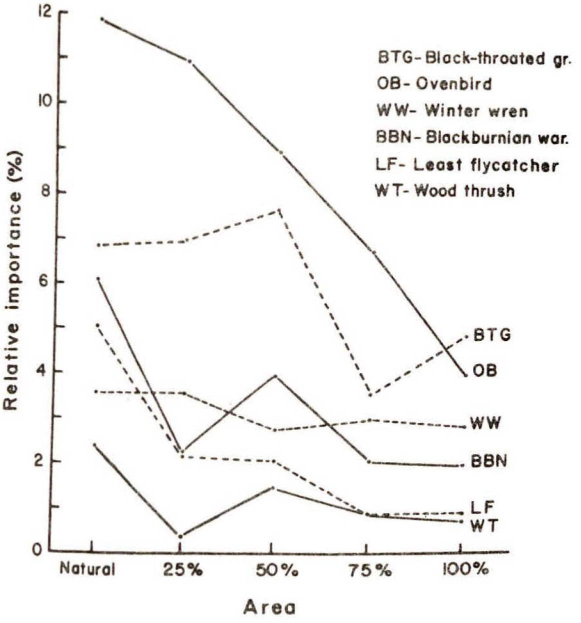

Figure 3.--Bird species showing decreasing trends in relative importance as a function of increasing habitat disturbance (modified from Webb et al., 1977).

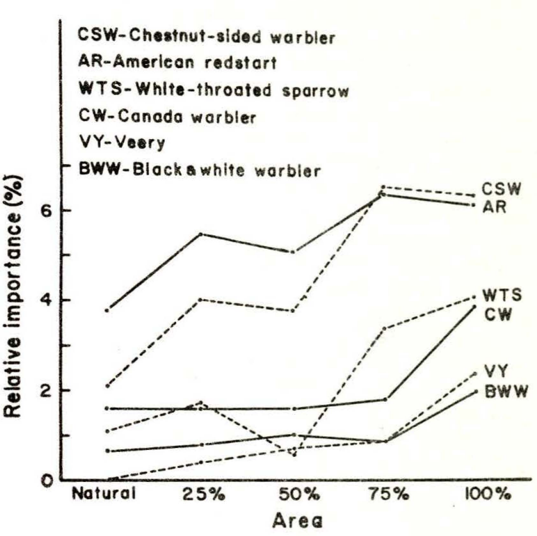

Figure 4.--Bird species showing increasing trends in relative importance as a function of increasing habitat disturbance (modified from Webb et al., 1977).

Webb, et al. (1977) conclude that logging in northern hardwood forests does not completely eliminate any breeding bird species. In addition, their results suggests that over the long term these avian communities are resilient to even severe habitat disturbance. However, we feel that the study of Webb et al. (1977) may suffer from some methodological inadequacies which lead us to question some of their conclusions.

The inadequacies we perceived are outlined below:

a) Population censusing techniques: Their method of calculating a population index not weighted by sampling area undoubtedly over-estimates true abundances. Their method is most problematic in the extensively logged habitats where increased visibility and decreased sound interference would likely result in the observer recording species over a much larger area. As a result, decreases in abundance may go unrecorded.

b) Breeding status unknown: The breeding status of individual birds was not determined and, like the population index, may be most problematic for the disturbed habitats. The logged stands were enclosed within an extensive undisturbed tract of forest which may have resulted in there being more rapid recolonization than would occur in more isolated forest plots. Also, recolonization, especially during the first few years following disturbance, may have been largely by non-territorial individuals excluded from surrounding undisturbed habitats. Stewart and Aldrich (1957) and Hensley and Cope (1951) have supplied evidence that a portion of the population of some species of these forests are composed of a floating population of unmated males. Disturbed, sub-optimal habitats may "collect" these unmated indivuduals.

c) Pooling of data: The only data available to the reader are the pooled population indices. Of most interest are the immediate effects of logging which would only be apparent from individual year censuses. As will become apparent later in our discussion, pooling may mask dramatic year-to-year fluctuations in species composition and relative abundance.

d) Exclusion of rare species: Most of the rare species were excluded from detailed analysis. Threatened or endangered species are most likely part of the rare component of any community. From a conservation perspective these are the species most in need of accurate censusing to determine the effect of various management practices on their populations.

e) Lack of quantitative vegetation data: Only a qualitative description of the forest type was given. As a result it was impossible to unambiguously assess the degree of habitat disturbance. Most lacking was a frequency distribution of trees by dbh size-class before and after logging.

COMMUNITY-LEVEL ANALYSIS

In order to resolve the direct effects of logging on community structure per se, we have analyzed the Webb data (Webb et al., and numerous other censuses in terms of their rank-abundance distributions (MacArthur, 1957, 1960; Whittaker, 1972). In addition to identifying changes in species composition, we analyze the rank-abundance distribution of each of the censuses according to their fit to various theoretical distributions. We then discuss the underlying biological assumptions of these theoretical rank-abundance distributions with regard to specific censuses. Specifically, we are interested in determining the effects on community structure of various intensities of disturbance. In addition, we divided the individual censuses into 1 of 2 groups, mature or disturbed (successional), and examined these data according to changes in the relative importance of various feeding guilds (Table 1).

Over the years avian ecologists have accumulated much information on the relative abundance of species occupying specific habitat types. Many researchers noted that the distribution of relative abundance in communities assumed a few characteristic patterns. Subsequently, models based on the interactions among populations within communities were proposed to account for the observed patterns of relative abundance. Specifically, MacArthur (1957, 1960) proposed several models of relative abundances based on different assumptions about the biological organization of the community.

For 2 of these models a stick, symbolic of a finite resource dimension, was broken into N segments, where N was equal to the number of species. In the first model N-1 points were picked at random along the stick, then the stick was broken at these points. The lengths of the resulting segments were proportional to the relative abundance of the species. In the second model, N independent pairs of points are successively chosen at random locations along the length of the stick. The length of the segment between a given pair of points is proportional to the species abundance. Both broken-stick distributions are specified by a single parameter, the number of species.

The biological assumptions of the first model are that the critical resources are continuously distributed along a single dimension, all resources are utilized, but the species do not overlap in their utilization of the resources (Ricklefs, 1973). The model is restricted to communities comprising a relatively limited number of related species competitively interacting in a structurally homogeneous habitat. This model is often referred to as the non-overlapping niche model (Fig. 5).

The second model assumes a much more even distribution of species abundances. The model rests on the assumption that the abundances of species are independent of each other; that

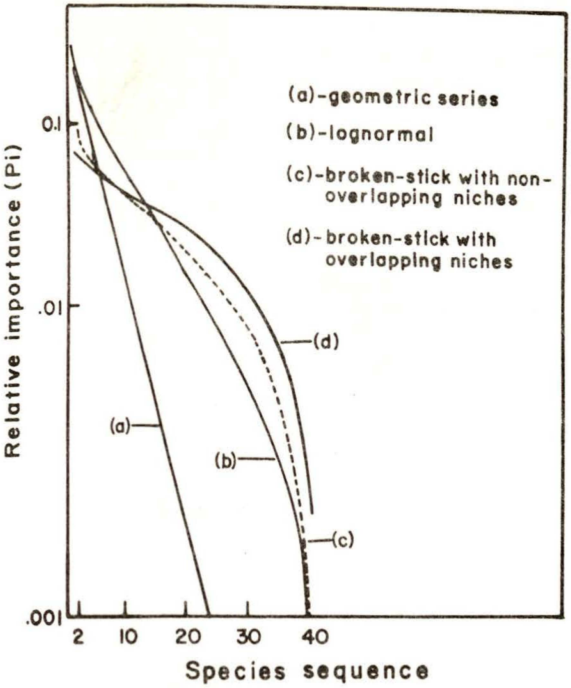

Figure 5.--Theoretical rank-abundance curves fit to 4 major hypotheses: a) geometric series (c = .750); b) lognormal distribution (a = .25, S_o = 6); c) non-overlapping niche hypothesis; d) overlapping niche hypothesis. All curves were calculated on the basis of 40 species.

is, species do not compete and resources are not fully utilized (Ricklefs, 1973). This model is referred to as the overlapping niche model (Fig. 5).

Observed bird species-abundance distributions show their best fit to the non-overlapping niche model (MacArthur, 1957, 1960; King, 1964; Longuet-Higgins, 1971). Deviations from this distribution most frequently result from too many common species and too few rare species. However, as pointed out by Cohen (1966, 1968) and others, the specific biological assumptions of the non-overlapping niche model are not always supported. Cohen (1968) was able to derive this same model by a completely different set of hypotheses. Even though the strict biological assumptions of this model are not validated, good fits to this distribution do indicate that some major factor is being roughly evenly apportioned among the constituent species of the community (May, 1975).

If the distribution of species relative abundance proceeds in a strictly hierarchial fashion we arrive at a geometric series distribution. In this model one assumes that the community is dominated by a single factor with a species success determined by its ability to preempt some fraction of the unutilized resources. The most successful species will preempt a fraction k of the resource and the second species a fraction k of the remainder, and so on resulting in a geometric distribution (Fig. 5). This distribution, referred to as the niche preemption model, is usually best fit by data from communities with few species characteristic of an early successional stage or occupying harsh environments (e.g., Whittaker, 1972). The phenomenon of strong dominance usually characterizes such circumstances.

If a variable such as relative abundance is determined by a large number of factors the distribution of that variable will be normal. In communities with many species and large numbers of individuals the distribution of relative abundances is often best described by the log normal (Fig. 5). Communities characterized by this distribution have many moderately abundant species and few common or rare species (Preston, 1948). The biological assumptions underlying this model are obscure and little can be deduced about the structure of communities fit by this distribution. The most consistent condition is the absence of any single, obvious controlling influence on the species' relative abundances.

RANK-ABUNDANCE ANALYSES

Figure 6 presents the rank-abundance results for the data from Webb *et al.* (1977). It is immediately apparent that there is very little difference in the general shape of the distributions. All curves are best fit by MacArthur's non-overlapping niche distribution (hereafter referred to as the broken-stick). The 100% curve also gives a moderately good fit to a lognormal distribution, probably because of this area's extreme heterogeneity represented by 10 years of pooled data. In general, polling of data over many years improved the fit to a broken-stick distribution for all types of forest stands we examined (see below). As mentioned previously, pooled data likely masks any of the immediate effects of logging on community structure. It would be of great interest to look at rank-abundance distributions for each of the stands on a yearly basis. Unfortunately, the annual data is not available.

These curves deviate from the theoretical broken-stick distributions by having too many common species and too few rare species. However, if broken-stick distributions are calculated on the basis of the number of observed ranks, and not on the number of observed species, all these curves are fit very accurately. Calculations of goodness of fit on

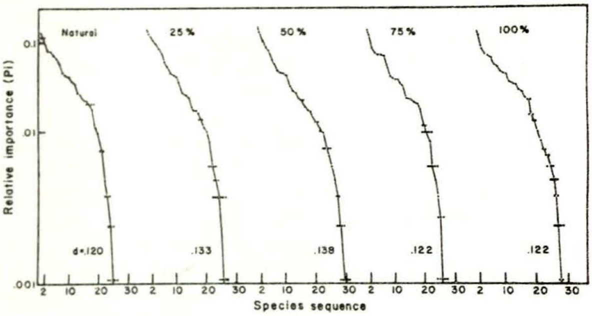

Figure 6.--Rank-abundance curves for the bird communities from the 5 areas of Webb *et al*., (1977). The d - values indicate the relative importance of the most common bird species, i ($d = n_i/N$total).

this basis seems reasonable: if the populations were perfectly sampled the probability of having 2 species with exactly the same number of individuals would be very small. Perfect sampling increases the number of ranks and usually decreases the dominance resulting in improved fits to the broken-stick distribution.

Rank abundance distributions well fit by a broken-stick model are characteristic of ecologically homogeneous groups of species which randomly apportion amongst themselves a fixed amount of some key resource (May, 1975). The implication from a comparison of these distributions (Fig. 6) is that this apparent mechanism of allocation of a major resource is not disrupted by logging. Our conclusion from this type of community-level analysis corroborates those reached by Webb *et al*. (1977). Northern hardwood bird communities appear to recover rapidly from habitat disturbance and, despite changes in species composition, community structure remains relatively stable.

Some questions remain, however, about the generality of this conclusion. We have already elucidated what we consider to be methodological difficulties with the Webb data. To unravel the effects of pooled data and to determine whether the conclusions reached by Webb *et al*. (1977) are consistent with other published data, we examined censuses from several disturbed northern hardwood forest communities. Most of the data were taken from breeding bird censuses published in American Birds (Audubon Field Notes).

When we examined other bird census data to test the generality of Webb's results we found that data directly comparable to their study were scarce. However, bird census data were available from a mature northern hardwood community both before, and after, logging (Fig. 7) (DeGarmo, 1948, 1953; Chandler, 1958; Harrison *et al*., 1964; Leitsch, 1968; Smith, 1973). This 15 acre plot, located in West Virginia, was selectively logged of most of its marketable timber in 1955, and we feel closely approximates the 75-100 percent logged areas of Webb *et al*. (1977) in degree of habitat disturbance.

The shape of the rank-abundance curves both before and after logging are very similar (Fig. 7). Therefore, logging appeared to have little effect on the overall community organization. All the single year censuses are best fit by geometric series and contrast sharply with the pooled distributions of Webb *et al*. (1977) (Fig. 6). These communities have low species diversity, high dominance, and

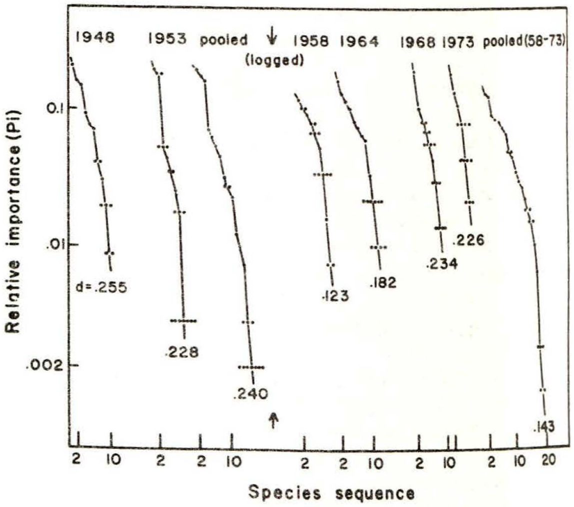

Figure 7.-- Rank-abundance curves for the bird communities of a hardwood forest plot before and after selective logging. Numbers above the curves indicate the year of the census. Pooled curves represent data combined over 2 or more years. d-values as in Fig. 6.

according to the biological assumptions underlying this model, should be characterized by a pattern of niche preemption.

Individual year censuses on this plot recorded few species and were marked by extensive year to year variability in the relative abundance and presence of the less common species. Only by pooling data over years do the rank-abundance curves approach the broken-stick distribution proposed by MacArthur (1957, 1960) as characteristic of temperate bird communities. Turnover of some portion of the rare species each year results in a much higher apparent species richness when the data are pooled. Up to some asymptotic limit, total species richness of a small plot may be a function of the number of years of study, a consequence of a great deal of variability in yearly species composition.

Our initial conclusions from these comparisons (Fig. 7) indicate that the avian community structure of this site was little affected by selective logging. However, unlike the Webb results, there was extensive turnover in species composition. Rufous-sided towhee, mourning dove, and chestnut-sided warbler appeared for the first time as the second, fourth, and fifth most dominant species, respectively.

In addition, there is a suggestion of a greater number of rare species in the undisturbed habitat relative to the logged habitat (Fig. 7). This is apparent from the number of ranks falling in the third log cycle. In this regard it may be significant that the 1948 census comprised only 7 man-hours and likely underestimated richness, particularly for the rare species.

To further test the sensitivity of rare species to logging, and the effects of habitat disturbance on northern hardwood forests in general, we contrasted rank-abundance curves representing the avian communities of mature (undisturbed) forests to those from successional and disturbed forests (Figs. 8-10).

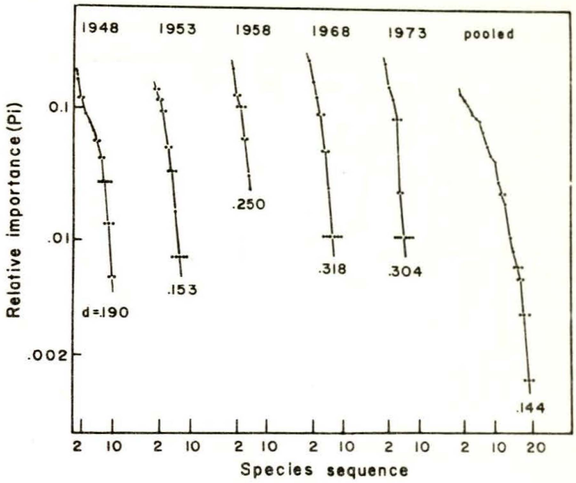

Figure 8.--Rank-abundance for the bird communities of a hardwood forest plot experiencing secondary succession. Labels as in Figs. 6 and 7.

Figure 8 represents a successional sequence of an initially disturbed northern hardwood forest in West Virginia. Censusing of this 15 acre plot began in 1948 and was continued intermittently until 1973 (DeGarmo, 1948; Brooks Bird Club, 1953; Baker _et al_., 1958; Hutton _et al_., 1968; Eddy _et al_., 1973). In 1948 the plot was a thicket with young trees 15-25 feet tall; by 1968 the plot was a young forest with most trees 4-8 inches dbh. Especially striking from this figure is that the rank-abundance curves showed no significant change in shape over the 25 year period. As with other censuses, a broken-stick distribution is approximated only by pooling data. In terms of nutrient pools and vegetation structure it may take a northern hardwood forest 60-80 years to recover from severe disturbance (Likens _et al_., 1978). What remains unclear is whether the avian communities of these forests show the same long-term recovery time. Data presented below (Fig. 10) indicates that these bird communities may still be showing the effects of past habitat alteration.

Annual rank-abundance curves are best fit but geometric series, have low species diversities and, in some years, high dominance. All the rank-abundance curves reveal a lack of rare species; i.e., those with relative abundances less than .01. Thus, our suggestion of a sensitivity to disturbance on the part of rare species is further substantiated.

The changes in species composition during succession closely correspond with those reported by Webb _et al_. (1977) for Adirondack forests. Species showing negative trends through succession were the veery, chestnut-sided warbler, mourning warbler, and rufous-sided towhee. Species with consistent positive trends were the wood thrush and black-throated green warbler.

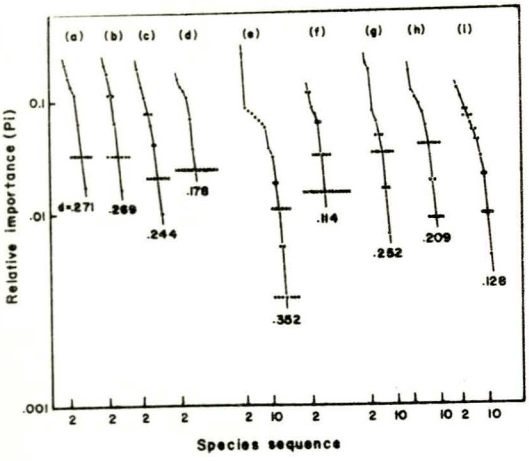

Figure 9.--Rank-abundance curves for the bird communities of successional and disturbed habitats: a-c) deciduous clearcuts 1, 3, and 4 years, respectively, after cutting; d-e) aspen-birch clearcuts 2 and 4 years, respectively, after cutting; f) an early successional hardwood forest; g) mature beech-maple-hemlock forest after an extensive natural disturbance; h) selectively cut-over forest; i) young red maple-gray birch forest. d-values as in Fig. 6.

Figure 9 presents rank-abundance curves for early successional and disturbed habitats. With the exception of Fig. 9e, all these single year curves are best fit by geometric series. Dominance varied appreciably, with some disturbed communities having surprising high equitability. The majority of these communities have few rare species, apparent from the figure as a lack of ranks in the third log cycle. A scarcity of rare species seems to be a relatively consistent trend in the disturbed communities that we examined. Figure 9e represents an exceptional case in terms of the extensively disturbed habitats we reviewed. However, it does indicate that a lack of rare species is not a universal response to habitat disturbance.

Admittedly, several of the curves in Fig. 9 illustrate severe habitat disturbance. However, to the extent that these curves convey actual community attributes, they illustrate that the species importance values of the community dominants are relatively immune to changes in habitat structure while the rare species previously occupying these habitats are often eliminated. Even though rare species are well represented in Fig. 9e, these species are not those characteristic of mature forests of this region and represent a turnover in the species composition of this group.

Relative to undisturbed forest communities these individual curves indicate little change in community structure (cp. Fig. 10). However, the species composition of many of these communities has changed dramatically. They are dominated almost exclusively by edge-species; most notably the chestnut-sided warbler, mourning warbler, rufous-sided towhee, veery, indigo bunting, and song sparrow. Forest interior birds have been completely eliminated from the heavily disturbed plots. The less severely disturbed forest habitats (Figs. 9g, h, i) remain dominated for the most part by birds characteristic of mature forests, but, significantly, these communities also show a loss of their rare species.

To substantiate the apparent trend in loss of rare species in early successional or disturbed hardwood forests, we have plotted for comparison a representative sample from bird communities occupying mature, undisturbed northern hardwood forests (Fig. 10). These rank-abundance curves contrast most obviously with the disturbed and successional habitats by the greater number of species whose relative abundances fall in the third log cycle. Thus, rare species appear to contribute substantially more to the species complement of communities of undisturbed forests than they do in disturbed areas. We feel this comparison clearly indicates a sensitivity on the part of the rare species component of undisturbed forests to habitat perturbations (cp. Figs. 7-9).

In agreement with the data from disturbed habitats, these rank-abundance curves are best fit by geometric series and do not approach broken-stick distributions unless censuses are pooled over years (Fig. 10e). In addition, even these unperturbed forests show considerable year to year variability in species composition, particularly pronounced as turnover in the identity of rare species. The variance in composition of the rare species group and relative abundances of even the community dominants, appears to be a common feature of the avian communities of north temperate forests.

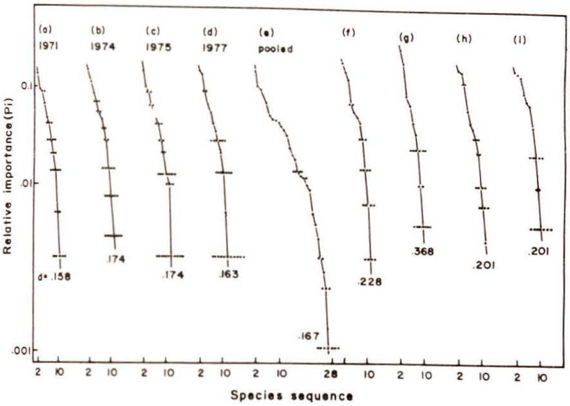

Figure 10.--Rank-abundance curves for the bird communities of mature, undisturbed northern hardwood forests: a-d) a forest plot censused over 4 intermittent years; e) pooled curve for the collective data of curves a-d; f) mature poplar forest; g) mature aspen-northern hardwoods forest; h) northern hardwoods forest; i) aspen-birch forest. Labels as in Figs. 6 and 7.

DISCUSSION

Our examination of the few published studies assessing the effect of forest management on avian communities revealed a lack of rigorous documentation of the response of birds to habitat change. From available data (e.g., Webb et al., 1977 and Kilgore, 1971) the implication is that even extensive logging results in few long term changes in bird community composition. This conclusion appears to be in contrast to recent theoretical work establishing a strong relationship between habitat structure and species composition. Furthermore, in species rich, equilibrium communities the habitat differences permitting competitive coexistence of similar species are often very subtle and perhaps essential to maintain high species richness (Noon 1977; Noon and Able, 1978).

Our comparison of rank-abundance curves, contrasting mature and disturbed forests in terms of the distribution of species abundances, largely supports the resilience of community structure. In terms of the fit of these curves to theoretical distributions we found little evidence of change in community structure as a consequence of disturbance. However, large scale changes in species composition occurred after disturbance in many communities. These changes were noted in 2 ways: as a change in community dominants and as a loss of rare species.

In addition, we uncovered some interesting facts pertaining to theoretical concepts of avian community structure. Specifically, we found few annual censuses whose rank-abundance curves conformed to broken-stick (non-overlapping, contiguous niches) distributions. Good fits have commonly been reported for temperate forest bird communities at equilibrium and occupying relatively homogeneous habitats (MacArthur, 1957, 1960; King, 1964). We feel that our selection of censuses meet the criteria of the broken-stick model and the lack of fit represents a real discrepancy.

The data we examined differed most apparently from the broken-stick distributions by having higher dominance, too many common species and too few rare species. As a consequence they were best fit by geometric series. Only by pooling censuses over several years did these curves approach a broken-stock distribution (i.e., Fig. 7). We believe this occurred because of the extensive variability in the composition of the rare species group. By pooling censuses over time additional rare species are accumulated, dominance decreases, and the fit to the broken-stick distribution improves greatly (i.e., Fig. 10e).

The most striking difference we noted in our comparison of mature, undisturbed habitats to disturbed or early successional habitats was a lack of rare species in the latter habitats. This was graphically portraited by there being few, or no, species falling in the third log cycle of rank-abundance curves from disturbed habitats. However, it is important to determine whether this observed difference in rare species is simply a statistical artifact of the data. If mature habitats had significantly higher species richness values or higher breeding densities, or both, these differences could account for the lack of rare species in disturbed habitats. To examine this possibility we have analyzed these (and others) community attributes from both mature and disturbed habitats (Table 2). First note that there is a significant difference in the mean number of species per third log cycle (Table 2). This difference is clearly independent of breeding density, but is complicated by a significant difference in species richness in favor of mature plots (Table 2).

To normalize for the difference in species richness we have independently calculated the percent of species in each census falling in the third log cycle. When we compare these 2 means we find that there is still a signifi-

Table 2. Comparison of avian community attributes of rank-abundance curves (Fig. 7-10) representing mature and disturbed, or early successional, hardwood forest areas. Given are means (standard deviations) and the significance of mean difference where applicable.

Attribute	Mature	Disturbed and Successional
Species diversity	2.567 (.288)	2.464 (.262)
Evenness	0.755 (.028)	0.780 (.064)
Species richness	24.6 (6.6)	17.6 (4.4)**[a]
Density (males per 100 acres)	228.3 (106.6)	198.4 (116.9)
Dominance (n_{max}/N)	0.215 (.062)	0.222 (.068)
No. of species per third log cycle	8.50 (3.75)	1.94 (2.80)***
Percent of species per third log cycle	32.8 (9.0)	9.5 (12.2)****[b]

[a] **, .005<p<.01; ***, .001<p<.005; ****p<.001

[b] arcsin transformation

cant difference in the proportion of rare species (Table 2). Thus, undisturbed plots have both a significantly higher absolute number, and proportion, of rare species.

It is difficult to specifically identify the rare species because of the great variability from site to site in the species composition of this group. However, there do appear to be consistently rare foraging guilds (Table 1). Examining the species composition of these guilds may give us insights into what species are most threatened by habitat disturbance.

The most obvious, and the most readily understood, are the birds of prey. These species are rare even in their preferred habitat, but they seem to be particularly rare in disturbed habitats (Table 1). A second rare foraging guild showing significant decrease as a result of disturbance were the bark drillers (Table 1). Woodpeckers seem to be adversely affected at all but the lightest levels of disturbance. The only woodpecker maintaining a high frequency in logged plots was the ground-foraging flicker. Conner _et al_. (1975) reported similar results from logged habitats in Virginia.

Both the bark gleaner and hover gleaner guilds were consistently rare. Both guilds show decreased frequency in disturbed habitats, but only the hoven gleaner is significant (Table 1). A common factor links many of the species composing the bark gleaner, bark driller, and predator guilds; that is, many of these species are hole nesters. The hole nesters also include a sallier, the great-crested flycatcher, which also showed a large decrease in frequency in disturbed habitats. Hole nesters were also seen to decrease as a result of logging in Finnish forests (Haapenen, 1965). There is a likely correlation between decreases in the woodpeckers, which are primary hole nesters, and secondary hole nesters such as chickadees and titmice which are indirectly dependent upon the presence of primary hole nesters.

Although not a rare guild, the salliers also showed a significant decrease in frequency in disturbed plots (Table 1). The decrease was most pronounced for the great-crested flycatcher, eastern phoebe, acadian flycatcher, eastern wood pewee, and the American redstart. Because most of these species are canopy or sub-canopy salliers their decrease in logged plots is easily understood.

From this admittedly limited (and highly variable) data set we suggest that extensive habitat disturbance may have its most pronounced effects on the rare species of the community. Their consistent rareness even in their preferred habitat is indicative of an extreme specialization to some aspect of their environment. Current evidence from temperate bird species indicates that their assessment of acceptable habitat is most frequently expressed as selection for specific structural features of the vegetation. If rare species normally have more stringent requirements in terms of habitat structure, then their sensitivity to habitat disturbance is easily understood. From a management perspective, identifying the specific requirements of these birds is of immediate importance and will require essentially an autecological approach. Until the requirments of these sensitive species are known, we suggest that the populations of the rare species characteristic of undisturbed forests be maintained at high levels by preserving extensive tracts of undisturbed forests. Currently, this appears as the sole means of assuring their persistence.

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LOWLAND HARDWOOD BIRD COMMUNITIES[1]

Fred B. Samson[2]

Abstract.--Lowland hardwood forests have declined in area since settlement, and precipitous decreases are reported in some states. Suitable silvicultural options for maintaining lowland hardwoods are selection and shelterwood cutting, but clearcutting should be avoided because of soil characteristics. The species-area concept may also be used in acquisition and in management of lowland hardwoods. Resource needs in the breeding or the non-breeding season for birds in the lowland hardwoods are little known nor investigated. Recommendations include preventing further loss of these forests, maintaining a diversity of tree species and stand ages by appropriate silvicultural option, and research to determine bird resource needs particularly during the non-breeding season.

INTRODUCTION

Nearly 50 years ago, Aldo Leopold wrote "The public is (and the sportsman ought to be) just as interested in conserving non-game species, forests, fish and other wildlife as in conserving game." He continued, "In the long run lop-sided programs dealing with game only, songbirds only, forests only, or fish only, will fail because they cost too much, use up too much energy in friction, and lack sufficient volume of support" (Leopold 1930: 287). However, only recently has the awareness and need for integrated management for all wildlife received its due attention. Legislation, including the Environmental Protection Policy Act of 1973, the Endangered Species Act of 1973, Forest and Rangeland Renewable Resource Planning Act of 1976, Land and Waters Resource Act of 1977 and other federal legislative or judicial acts point to the recent increase in professional and public awareness of nongame wildlife. Concurrent with the federal activity has been the passage of legislation or regulations by states supportive of nongame wildlife. Examples include legislation to protect endangered or threatened species (including at least 8 north central or northeast states), "nongame" stamps providing revenues to support research and management of nongame wildlife, and a constitutional amendment passed in Missouri which provides one-eighth of one percent of general sales tax revenues to game and nongame wildlife research and habitat management programs. Finally, as Allen (1973:21) pointed out in the Report to the Committee on National American Wildlife Policy, programs should "recognize that all peoples have a common concern for the survival of plants and animals still existing on earth. We regard this as a feature of the right-to-live concept already advanced. In a utilitarian sense, the preservation of species leaves options open for generations to come, who may find unpredictable uses for many organisms."

Among all terrestrial vertebrates, birds have been particularly successful in exploiting a wide array of aquatic and terrestrial habitats (Dorst 1974). Of these, lowland hardwoods, whether in tropical or temperate latitudes, are particularly important (Ferguson et al. 1975, Pearson 1977, Johnson and Jones 1977, Dickson 1978 and others). The high net productivity of lowland forest trees are influenced by many factors including light, temperature, and the high availability of soil moisture and nutrients (Ricklefs 1973, Whittaker 1975).

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These factors, particularly the availability of nutrients and moisture, have in part contributed to the vast conversion of lowland hardwoods to agricultural crops (Graber and Graber 1976, Korte and Fredrickson 1977, Giulio 1978 and others). Additionally, stream or river channelization for flood control by the Army Corps of Engineers and the Soil Conservation Service and authorized under Public Law 566 has reduced overall acreages of lowland hardwoods. The Soil Conservation Service (1975) has recently reported that over 15,540 km of streams or rivers have been affected, with an additional 18,440 km scheduled for alteration for flood protection. Additionally, applications have been filed for channel modification work involving approximately 91.4 million hectares with planning authorizations issued for approximately 51.8 million of these hectares.

Estimates of presettlement (about 1650) areas of lowland hardwoods are difficult to obtain, but unquestionably these acreages in several northeast and north central states have decreased since settlement (Table 1). Examples of very serious losses include Missouri, wherein about 4% of the presettlement southeastern lowland hardwoods remains today, with only 5860 (0.6%) hectares of the original 971,260 hectares in public ownership (Korte and Fredrickson 1977). In Ohio, less than 5% of an estimated original 80,938 hectares of lowland hardwood remains (Gebhart pers. comm.). Unfortunately, estimates of losses of lowland hardwoods are not available for all states, nor can the overall impact of their loss for wildlife ever be clearly determined. However, studies by Bonnema (1972) in Minnesota, New (1972) in Indiana, and Passordt and Dodge (1975) in Vermont provide examples of the damaging effect of stream modification on wildlife including many nongame avian species.

Currently, there are about 14.3 million hectares of lowland hardwoods in the northeast and north central states (Table 1). Some recent increases in lowland hardwood acreages are evident in New York and Rhode Island, where small farms, no longer economically profitable, are reverting to natural habitats.

FOREST SUCCESSION AND MANAGEMENT

Lowland forests contrast with upland forests in number of tree species present (generally more) and their often patchy distribution (Solomon 1977). These differences reflect the effects of periodic flooding, floods of varying duration, structural damage from ice or debris, and shifts in soil texture and layering as the result of flood activity (Lindsey et al. 1961, Johnson and Bell 1976, Huffman 1977). Of these, Bendinger (1971) described flood frequency and duration as most important in determining distribution of plant species on a flood plain. The irregular horizontal and vertical distribution of the alluvial soils and the dynamic nature of the ecotype influence the relatively high plant species diversity. Tesky and Hinckley (1978), however, have pointed out that these microhabitat characteristics lessen or preclude the opportunity to place lowland hardwoods in the ecoregions or macro-vegetation groupings suggested by the USDA (1949), Kuchler (1964), Braun (1972), and recently by Bailey (1978). The characteristics influence a pattern in lowland hardwood forest succession which is generally similar through most of the northeast and north central states.

Forest succession and composition reflect the interaction of a moisture-nutrient-soil gradient and the shade tolerance of the species forming a plant community (fig. 1). Early successional stages are often characterized by species intolerant of shade yet requiring a moist soil for seed germination. On a flood plain, "new ground" is regularly added through silt deposits. The new soils are often a diverse array of sand of different particle sizes and soil of varying textures. Pioneer tree species, cottonwoods and willows, require a moist mineral soil for seed germination. Because they often are prolific seed producers, they frequently develop into dense stands, competitively eliminating other species. Although tolerant to flooding (Table 2), neither species, particularly the willows, tends to succeed itself due to their shade intolerance. Thus, species more tolerant to shade and flooding including maples (silver and red), boxelder, sycamore, hackberry, ash (green, white, black), and elms form a second stage in succession. Late stages of succession are formed by species intolerant to flooding but shade tolerant including beech, basswood, sugar maple, yellow poplar, white oak in the northeast and north central states and in more southern states hickories, pecans, and several oaks. The time required to evolve to a stable or climax stage for a mesic or lowland stand of shade-tolerant species may exceed that for an upland more xeric stand (Peet and Louks 1977), an important consideration for forest management or modeling. However, soils supporting these late successional stands may be lost to erosion during floods. Thus, the lowland hardwood ecotype is dynamic, with

Table 1.--Estimated area of lowland hardwoods (elm-ash-cottonwood or maple-beech-birch) in north central and northeast states

Locality	Current area (ha)	Percent change during interval	Source
Connecticut	290,290		Dickson and Bowers (1976)
Delaware	32,900		Ferguson and Mayer (1973)
Illinois	335,460	-25 to 28.6, 1962-1973	Graber and Graber (1976)
Indiana	510,600		Spencer (1969)
Iowa[1]	168,500		Ostrom (1974)
Kentucky[1]	926,830		Kingsley and Powell (1978)
Maine[2]	693,650		Ferguson and Kingsley (1972)
Maryland	211,500		Powell and Bowers (1978)
Massachusetts	479,400		Peters and Bowers (1977)
Michigan	769,000	-20.8 presettlement to date	Chase *et al*. (1970); W. B. Bottie (pers. comm.)
Minnesota[3]	515,980	-5 to 10, 1968-1978	W. Hanson (pers. comm.)
Missouri	435,530	-25.5, 1959-1972	Spencer and Essex (1972)
New Hampshire	827,960	-9.5, 1948-1973	Kingsley (1975)
New Jersey	152,570		Ferguson and Mayer (1974)
New York	3,692,000	+10 to 30, 1950-1968	Ferguson and Mayer (1970)
Ohio	4,040	-95, presettlement to date	E. J. Gebhart (pers. Comm.)
Pennsylvania	2,281,260		USDA (1975), J. D. Hassinger (pers. comm.)
Rhode Island	1,200	+25, 1953-1972	D. C. Holt (pers. comm.)
Vermont	1,047,000		Kingsley (1977)
West Virginia	1,389,360		Barnard and Bowers (1977)
Wisconsin	468,600	-56.4 presettlement to 1968	M. E. Reinke (pers. comm.)

[1] Data for only commercial forest lands.

[2] Data for elm-ash-red maple.

[3] Data for two of four management units.

erosion altering late successional stages and with early stages created by the same flood activity.

FOREST MANAGEMENT PRACTICES

Lowland hardwoods can be managed for lumber, water, wildlife, recreation or any combination of these. The management goal(s), species-site relationships, and stand composition determine the approach to regeneration (Dickson 1978).

Selection, shelterwood, and clearcutting are employed (Table 2) in the north central states on well-drained sites where sugar maple-basswood or yellow birch dominate. Selection results in many aged stands and a predominance of shade-tolerant species; whereas, shelterwood with removal of advanced regeneration leads to a moderately tolerant or tolerant species composition (Tubbs 1977). Although clearcutting creates overstory openings, the sand, silt, and clay soils characteristic of floodplains are vulnerable to invasion of grass, herbaceous, or bushy species that may prevent regeneration of desired tree species. On wet sites where red maple, black ash, yellow birch, and elm predominate, individual tree selection is used when timber harvest is the objective (Tubbs 1977).

Suitable silvicultural options in the northeastern states also are influenced by site productivity, species composition, age distribution, and management objectives (USDA 1973). Trees harvested singly or in groups meet recreational or esthetic goals. Even-aged management, primarily clearcutting, results in a mixture of species and is used where light-demanding species are a management objective (Leak and Wilson 1958).

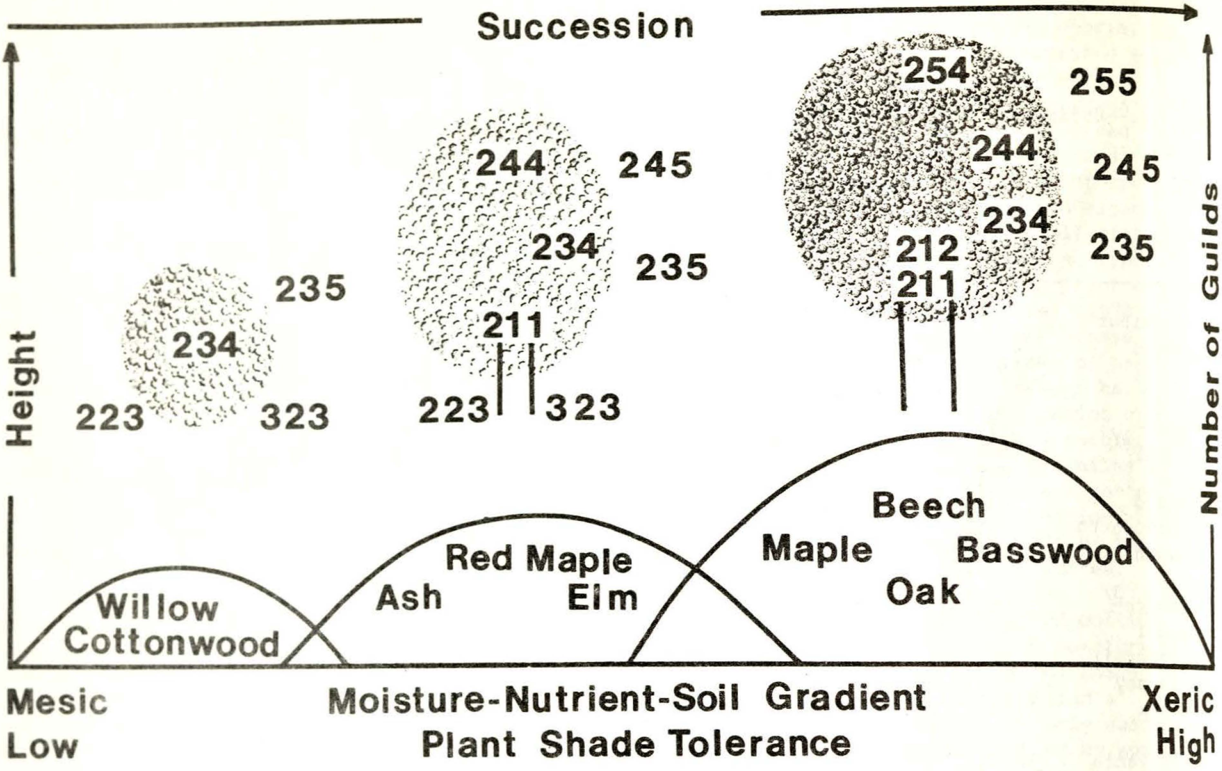
Succession
Height
Number of Guilds
235
234
223
323
244
245
234
235
211
223
323
254
255
244
245
234
235
212
211
Willow
Cottonwood
Red Maple
Ash
Elm
Beech
Maple
Basswood
Oak
Mesic
Low
Moisture-Nutrient-Soil Gradient
Plant Shade Tolerance
Xeric
High

Figure 1.--Relationship of avian guild and forest succession in the lowland hardwoods in the northeast and north central states. Guild membership is listed in Table 3.

Information on shelterwood cutting in the northeast is lacking and its use is therefore limited (Filip and Leak 1973). Management guidelines for lowland hardwoods in the Appalachian oak area have recently been reported in detail by Hooper (1978).

Shade-intolerant species, particularly cottonwoods, but including sycamore and sweet gum, are being managed through clearcutting in Missouri and other southern states. The impact of these monocultures on wildlife is not clearly known, although their value appears less than that of natural diverse stands of lowland hardwoods.

BIRD POPULATIONS IN THE BREEDING SEASON

Species-area Relationships

Plant ecologists for many years have asserted that habitat size is a significant factor in determining numbers of plant species present (Gleason 1922, Cain and Castor 1959, Preston 1960, Greg-Smith 1969, and others). Numerous studies of terrestrial vertebrates on archipelagos or islands (Koopman 1958, MacArthur and Wilson 1967, Diamond 1969, Terborgh 1973, McNeil and Cody 1978, and others) have empirically verified that the number of species can be predicted by area and, in some instances, have discussed the area required for long-term survival of populations. A number of authors also have recently pointed out the usefulness of this concept in the design of wildlife or natural areas (Terborgh 1974, Diamond 1975, May 1975, Slayter 1975, Wilson and Willis 1975, Miller and Harris 1977, and others). Additionally, a number of investigators have provided evidence that size of an inland forest fragment or "island" can be used to predict the number of avian species present (Moore and Hooper 1975, Graber and Graber 1976, Galli et al. 1976, Gavareski 1976, Howe and Jones 1977, Tilghman 1977). Although this concept will be covered in detail elsewhere in these proceedings, two land-use implications are important in considering avian use of lowland hardwoods.

Figure 2 depicts a curvilinear relationship between size of a deciduous

Table 2. Response to flooding or shade and silvical options for major lowland hardwood species. (Response to flooding after: McDermott 1954, Hall and Smith 1955, Wistendahl 1958, Curtis 1959, Lindsey et al. 1961, Dickson et al. 1965, Rochow 1974, Brunk et al. 1975, Solomon 1977, Tesky and Hinckley 1978; silvical options after: USDA Forest Service 1973.)

Species	Response to flooding/shade	Silvical options
Boxelder (*Acer negundo*)	Tolerant/intermediate	
Red maple (*A. rubrum*)	Tolerant/intermediate	Selective, shelterwood
Silver maple (*A. saccharinum*)	Tolerant/intermediate	Selective, shelterwood
Sugar maple (*A. saccharum*)	Intermediate/intermediate	Selective
Yellow birch (*Betula alleghaniensis*)	Intermediate/intermediate	Selective, shelterwood
River birch (*B. nigra*)	Intermediate/intermediate	Clearcut
Bitternut hickory (*Carya cordiformis*)	Intermediate/intermediate	Group selection
Pecan (*C. illinoensis*)	Intermediate/intermediate	Selection cutting
Shagbark hickories (*C.* spp.)	Intolerant/tolerant	Group selection
American beech (*Fagus grandifolia*)	Intolerant/tolerant	Selection cutting
White oak (*Quercus alba*)	Tolerant/intolerant	Group selection
Green ash (*Fraxinus pennsylvanica*)	Tolerant/intolerant	Selection cutting
Black ash (*F. nigra*)	Tolerant/intolerant	Selective, shelterwood
Black walnut (*Juglans nigra*)	Intolerant/tolerant	Selection cutting
Yellow poplar (*Liriodendron tulipifera*)	Intolerant/tolerant	Selection cutting
American sycamore (*Platanus occidentalis*)	Tolerant/intolerant	Clearcut
Eastern cottonwood (*Populus deltoides*)	Tolerant/intolerant	Clearcut
Swamp cottonwood (*P. heterophylla*)	Tolerant/intolerant	Clearcut
American elm (*Ulmus americana*)	Tolerant/intermediate	Selective,shelterwood
Basswood (*Tilia americana*)	Tolerant/intermediate	Selective
Sandbar willow (*Salix interior*)	Tolerant/intolerant	
Black willow (*S. nigra*)	Tolerant/intolerant	
Swamp white oak (*Quercus bicolor*)	Tolerant/intolerant	Group selection
White oak (*Q. alba*)	Intolerant/tolerant	Group selection
Northern red oak (*Q. rubra*)	Intolerant/tolerant	Group selection

forest fragment and number of avian species present in four different forest types. Thus, in order to maintain maximum regional avian diversity (as indicated by each curve in figure 2), top priority should emphasize identification and protection of large forests rather than an equal area of small forests (Forman *et al*. 1976). Second, there is a minimum point (similar to that defined by Goodall 1952, Cain and Castor 1959, and Greg-Smith 1969) on a species-area curve where a 5% increase in number of avian species would require a doubling in size of the forest fragments. Forman *et al*. (1976) suggested that this minimum point may be useful in size-related land-use decisions unless specific requirements for species that require even larger forest fragments must be met. Additionally, the configuration of the woodlot may be important; Stauffer (1978) reported a significant relationship between bird species richness and width of stream-side habitat.

Breeding Bird Populations--Precautions

The number of singing males either mapped or incorporated into an index is often the basis for estimating number of territorial males (Williams 1936, Enemar 1959, Robbins 1970) or as the focal point for evaluation of breeding habitat (James 1971, Shugart and James 1973, and others). Yet controversy in use of this technique remains. The interpretation of singing male data relative to the actual number of breeding males or to territorial function is complicated. In some species, song does not have a site-specific territory-related function (Thorpe 1958, Thompson 1960, Baptista 1972, Catchpole 1973, 1977, Marler and Mundinger 1975, Samson 1978, and others). Nor, has the role or function of song in a behavioral-ecological context been examined in detail for many avian species.

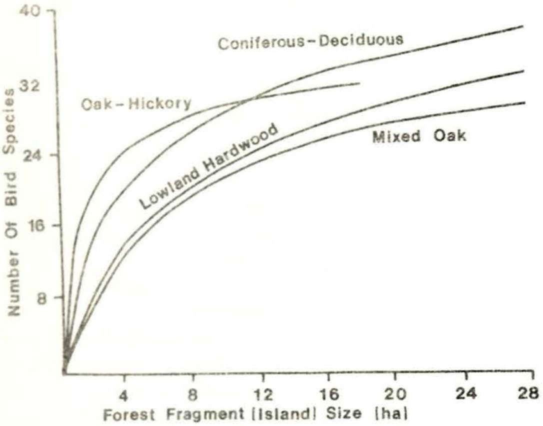

Figure 2.--Avian species--area relationships in four different continental forest habitats at mid-latitudes. Coniferous-deciduous after Moore and Hooper (1975), lowland hardwoods after Graber and Graber (1976), mixed oak after Galli et al. (1976), and oak-hickory after Tilghman (1977).

Additionally, as early as 1961, Thorpe, in an initial important review of avian vocalizations, pointed out that non-breeding males sing more often than breeding males. Studies of a diverse array of species including bobwhite, *Colinus virginianus* (Stoddard 1931), English robin, *Erithacus rubecula* (Lack 1946), song sparrow (Nice 1943), snow bunting, *Plectrophenax nivalis* (Tinbergen 1939), white-throated sparrow (Falls 1969), field sparrow (Best 1977), mourning dove (Baskett *et al*. 1978), fox sparrow (Martin 1978), prairie warbler, *Dendroica discolor* (Nolan 1978), and Cassin's finch, *Carpodacus cassinii* (Samson 1978) support Thorpe's contention. The potential bias of higher singing rates by non-breeding birds on estimates of breeding numbers is not precisely known, but it cannot be disregarded. Recent experimental studies of Orians (1961), Carrick (1963), Jenkins *et al*. (1963), Nolan (1963), Knapton and Krebs (1974), Power (1975), Samson (1976), and Thompson (1977) as well as "natural experiments" reported by Meunier (1960), Dixon (1963), Delieus (1965), Smith (1978), and others have all reported the existence of non-breeding birds, representing in one study upward to 67% of males present (Best 1975). Thus, considerable caution must be exercised when relating number of singing males to the concept of territory, to number of breeding birds, and to the analysis of breeding habitat.

A final consideration is the effect of events of the non-breeding season on subsequent densities of a breeding population. Lack (1966) argued that annual changes in breeding numbers of birds, both annual residents and migrants, reflected food-related mortality from early fall through winter. Supporting data for parids provided by Lack correlated breeding numbers which changed from year to year to fall mast production, particularly of beech. Subsequent studies by Newton (1964), Fretwell (1969, 1972), Pulliam and Enders (1971), Krebs (1971), Davis (1973), Samson (1976, 1978), Slagsvold (1975), Jones and Ward (1976), and others all support the contention that size of a breeding population reflects or is influenced by the events of the non-breeding season.

Guild-habitat Associations

The analysis of avian communities in different localities has provided insight into concepts of ecological equivalence as well as the association with habitat parameters including the vertical foliage structure (MacArthur and MacArthur 1961), successional stage (Karr 1968, Shugart and James 1973), foliage volume (Willson 1974), horizontal heterogeneity (Roth 1976), and a moisture gradient (Smith 1977). These studies have used a diversity index approach to relate the structure of an avian community to habitat or a multivariate statistical approach to describe avian species or family habitat needs. However, Maguire (1973) and Willson (1974) suggest a detailed analysis of guilds and resource availability may be necessary to clarify the impact of vegetational complexity on avian diversity.

A guild may be defined as "a group of species that exploit the same class of environmental resources in a similar way... without regard to taxonomic position" (Root 1967:335). Advantages of the use of guilds include directing attention toward all species regardless of taxonomic similarity, defining which set of conditions are necessary for a species or group of species to exist in a habitat type, and comparing communities where it is impractical to consider all species using an ecotype. This last advantage of the use of a guild approach is particularly important in reviewing avian use of lowland hardwoods since about 140 avian species may nest in this habitat type. Of the 140 species, raptors and wading birds will be discussed in detail elsewhere in the proceedings.

Breeding bird habitat (fig. 1) in lowland hardwoods can be divided into 3 categories: (1) willow-young cottonwood (early stage of succession), (2) red maple-ash (intermediate stage of succession), and (3) beech-maple-basswood or oak (mature forest, late successional stage). Birds using these habitat categories can be divided by guilds characterized by a 3-digit (ABC) number (table 3) where A is the primary food habit, B is the stratum most often used for foraging, and C is the common foraging behavior.

When willows or cottonwoods or both invade new alluvium, insectivorous foliage gleaning (234) and flycatching guilds (235) accompany insectivore (223) and omnivore ground gleaning (323) guilds (fig. 1). Dependent upon geographic locale, the Kentucky warbler (234), chestnut-sided warbler (234), yellow warbler (234), common yellowthroat (234), white-eyed vireo (234), Wilson warbler (233), Louisiana waterthrush (223), and brown thrasher (323) are among the species of this successional stage. The wood thrush (323), hermit thrush (323), winter wren (234), mourning warbler (234), least flycatcher (235), acadian flycatcher (235), cardinal (334), rufous-sided towhee (334), fox sparrow (334), Lincoln sparrow (334), swamp sparrow (334), song sparrow (334), white-throated sparrow (334) may also nest in brushy areas or in the understory of early to middle successional stages.

When a tree layer develops, several additional guilds are added including an insectivorous (244) and omnivorous (344), while the insectivorous low flycatching (235) may be lost. Examples include the downy woodpecker (211), hairy woodpecker (211), black-billed cuckoo (244), Carolina chickadee (244), black-capped chickadee (244), tufted titmouse (244), and northern oriole (344), depending upon region. As the forest becomes serially mature, additional guilds are insectivorous bark gleaners (212), insectivorous middle canopy gleaners (245), high canopy gleaners (254) and flycatchers (255). The brown creeper (212), white-breasted nuthatch (212), American redstart (245), parula warbler (244), scarlet tanager (254), yellow-throated vireo (254), red-eyed vireo (254), cerulean warbler (254), pileated woodpecker (211), red-bellied woodpecker (211), and great-crested flycatcher (255) are examples depending upon geographic locale. Thus, in lowland hardwoods, there is a stepwise progression evident wherein guilds are added or deleted dependent upon the structure and age of the vegetation. Members of each guild share similar food habits and foraging behavior and stratum, but membership in each guild will vary from location to location as species distribution patterns change.

Nesting Densities

Factors influencing nest site selection are complex in lowland hardwoods. Some species, the common flicker, pileated woodpecker, red-bellied woodpecker, red-headed woodpecker, yellow-bellied sapsucker, hairy woodpecker, and downy woodpecker, excavate a cavity in a dead or live tree or shrub. These cavities subsequently are used by the white-breasted nuthatch, black-capped chickadee, Carolina chickadee, and tufted titmouse. These species may also excavate their own cavities in soft rotting wood. The tree swallow, prothonotary warbler, and great crested flycatcher also will use a natural cavity or an old woodpecker hole (Conner 1978). Along stream banks, the kingfisher excavates a cavity along river bluffs. Other species with specific habitat needs include Swainson's warbler for giant cane (Arundinaria gigantea) and the parula warbler's association with Spanish moss and in northern states with lichen (Usuea sp.) (Eddleman 1978).

The relationship between number of singing males and actual number of nests has been reported for several habitats (Svensson 1974, Jensen 1974) but not in depth in lowland hardwoods. Results of these studies vary from Svensson's (1974) view that mapping of singing males represents a reasonable compromise in estimating breeding population size to Jensen (1974) who, after an in depth study of color-marked individuals of 15 species, concluded that at least in wetlands the mapping method was useless. However, using the mapping method and H', a species diversity index (Shannon 1948), Willson (1974:1018) reported a more diverse avifauna (i.e., a higher BSD) in bottomland forests (1.216-1.158), versus those in grasslands (.478-.727), old fields (.515-.595), upland forests (1.165-1.193) but not in a forest edge (1.272-1.270). Other examples of the diverse lowland difference drawn from the annual singing male census reports (Van Velzen 1975, 1977) include 26 species in 7.6 ha of mature lowland hardwoods in Maryland and 48 species in 18.5 ha of less mature lowland hardwoods also in Maryland versus 24 species per 11 ha and 23 species per 20 ha in upland forests in northern Virginia.

Table 3. Feeding guild and territorial males per 20 ha (raptors and wading birds excluded). Guilds are characterized by a 3-digit (ABC) number where: A = primary food habits (1) seedeater, (2) insectivore, or (3) omnivore; B = stratum most often used for foraging (1) bark, (2) ground, (3) low, (4) middle, or (5) high canopy; and C = common foraging behavior (1) bark drill, (2) bark glean, (3) ground glean, (4) foliage glean, (5) sally, or (6) fruit or buds (after Willson 1974). Number of territorial males are from the thirty-ninth and fortieth breeding bird census (Van Velzen 1975, 1977).

Species	Guild	Number of territorial males per 20 ha habitat, and state
Mourning dove (*Zenaida macroura*)	123	0.6, mixed mesophytic, OH
Yellow-billed cuckoo (*Coccyzus americanus*)	244	1.4, beech-oak, OH
Black-billed cuckoo (*C. erythrophthalmus*)	244	0.2, mixed mesophytic, OH
Common flicker (*Colaptes auratus*)	323	2.4, ash-basswood, NY
Pileated woodpecker (*Dryocopus pileatus*)	211	2.4, ash-basswood, NY
Red-bellied woodpecker (*Centurus carolinus*)	211	7.7, hickory-ash, oak, MO
Red-headed woodpecker (*Melanerpes erythrocephalus*)	211	4.2, mixed hardwood, MI
Yellow-bellied sapsucker (*Sphyrapicus varius*)	211	2.8, oak-hickory, OH
Hairy woodpecker (*Picoides villosus*)	211	1.8, birch-basswood, PA
Downy woodpecker (*P. pubescens*)	211	1.8, birch-basswood, PA
Great crested flycatcher (*Myiarchus crinitus*)	255	9.8, red maple-birch, NY
Eastern phoebe (*Sayornis phoebe*)	235	2.9, birch-maple, CT
Acadian flycatcher (*Empidonax virescens*)	235	10.9, birch-basswood, PA
Alder flycatcher (*E. alnorum*)	235	2.3, shrub, NY
Least flycatcher (*E. minimus*)	235	4.9, ash-basswood, NY
Eastern wood pewee (*Contopus virens*)	245	27.1, ash basswood, NY
Tree swallow (*Iridoprocne bicolor*)	234	1.9, maple-pine, ME
Blue jay (*Cyanocitta cristata*)	334	2.5, ash-maple, NY
Common crow (*Corvus brachyrhynchos*)	323	2.0, second growth hardwoods, CT
Black-capped chickadee (*Parus atricapillus*)	244	12.3, ash-basswood, NY
Carolina chickadee (*P. carolinensis*)	244	7.3, hickory-ash-oak, MD
Tufted titmouse (*P. bicolor*)	244	5.4, birch-basswood, PA
White-breasted nuthatch (*Sitta carolinensis*)	212	1.8, birch-basswood, PA
Red-breasted nuthatch (*S. canadensis*)	212	0.2, mixed mesophytic, PA
Brown creeper (*Certhia familiaris*)	212	1.8, birch-basswood, PA
House wren (*Troglodytes aedon*)	234	22.2, ash-basswood, NY
Winter wren (*T. troglodytes*)	234	0.1, mixed upland, NY
Carolina wren (*Thryothorus ludovicianus*)	234	3.6, birch-basswood, PA
Gray catbird (*Dumetella carolinensis*)	234	2.5, ash-basswood, NY
Brown thrasher (*Toxostoma rufum*)	323	0.7, upland-swamp, MA
American robin (*Turdus migratorius*)	323	20.0, ash-basswood, NY
Wood thrush (*Hylocichla mustelina*)	323	20.0, ash-basswood, NY
Hermit thrush (*Catharus guttata*)	323	3.8, maple-pine, ME
Veery (*C. fuscescens*)	323	20.0, ash-basswood, NY
Eastern bluebird (*Sialia sialis*)	335	4.6, red maple, NY
Blue-gray gnatcatcher (*Polioptila caerulea*)	235	4.8, birch-basswood, PA
Cedar waxwing (*Bombycilla cedrorum*)	146	2.4, ash-basswood, NY
White-eyed vireo (*Vireo griseus*)	234	5.0 birch-oak, WV
Yellow-throated vireo (*V. flavifrons*)	254	6.6, birch-oak, WV
Red-eyed vireo (*V. olivaceaus*)	254	12.3, ash-basswood, NY
Warbling vireo (*V. gilvus*)	244	14.8, ash-basswood, NY
Prothonotary warbler (*Protonotaria citrea*)	234	2.6, flood plain forest, MD
Swainson's warbler (*Limnothlypis swainsonii*)	234	
Northern parula warbler (*Parula americana*)	244	1.2, birch-basswood, PA
Yellow warbler (*Dendroica petechia*)	234	29.6, red maple-birch, NY
Black-throated blue warbler (*D. caerulescens*)	234	1.3, deciduous-coniferous, VT
Cerulean warbler (*D. cerulea*)	254	4.8, birch-basswood, PA
Chestnut-sided warbler (*D. pensylvanica*)	234	4.0, second growth hardwood, CT
Ovenbird (*Seiurus aurocapillus*)	323	4.9, red maple-birch, NY
Northern waterthrush (*S. noveboracensis*)	323	3.1, red maple-pine, NY
Louisiana waterthrush (*S. motacilla*)	223	2.4, birch-basswood, PA
Kentucky warbler (*Oporornis formosus*)	234	3.6, streamside, PA
Common yellowthroat (*Geothlypis trichas*)	234	17.3, red maple-birch, NY

Table 3.--Continued

Species	Guild	Number of territorial males per 20 ha habitat, and state
Yellow-breasted chat (Icteria virens)	244	26.6, brushy hillside, WV
Mourning warbler (O. philadelphia)	234	25.9, ash-basswood, NY
Hooded warbler (Wilsonia citrina)	234	0.5, hickory-oak, MD
Wilson's warbler (W. pusilla)	233	
American redstart (Setophaga ruticilla)	245	19.7, ash-basswood, NY
Common grackle (Quiscalus quiscula)	323	17.3, red maple-birch, NY
Brown-headed cowbird (Molothrus ater)	323	5.3, hickory-ash-oak, MO
Northern oriole (Icterus galbula)	344	22.2, ash-basswood, NY
Scarlet tanager (Piranga olivacea)	254	0.6, mixed mesophytic, OH
Cardinal (Cardinalis cardinalis)	334	4.9, ash-basswood, NY
Rose-breasted grosbeak (Pheucticus ludovicianus)	346	2.5, red maple-birch, NY
Indigo bunting (Passerina cyanea)	344	4.9, ash-basswood, NY
Rufous-sided towhee (Pipilo erythtophthalmus)	344	12.3, ash-basswood, NY
Chipping sparrow (Spizella passerina)	334	7.4, ash-basswood, NY
Field sparrow (S. pusilla)	334	1.3, upland forest, NY
White-throated sparrow (Zonotrichia albicollis)	334	14.8, red maple-birch, NY
Lincoln sparrow (Melospiza lincolnii)	334	
Swamp sparrow (M. georgiana)	334	4.1, swamp forest, IN
Song sparrow (M. melodia)	334	14.8, red maple-birch, NY

Nesting densities in lowland forests also may exceed other habitats. Examples include 211 singing males per 40.4 ha in a Maryland hickory-oak-ash flood plain forest and 488 per 40.4 ha in a mature deciduous flood plain forest versus 162 per 40.4 ha and 108 per 40.4 ha in an upland oak-hickory forest and upland tulip tree-oak forest respectively in northern Virginia (Van Velzen 1975, 1977). In Pennsylvania, 255 singing males per 40.4 ha were reported in a stream valley-mixed mesophytic forest compared to 163 males per 40.4 ha on a mountain oak-maple forest (Van Velzen 1975, 1977). Carter (1967), Tramer (1969), Blem and Blem (1975), Whitcomb (1977) and Stauffer (1978) also have reported increases in density of breeding birds from herbaceous habitats, to upland, to flood plain habitats.

Nesting Habitat

Although habitat selection by singing males has been examined in several habitats, few published reports describe nest site selection or habitat factors that affect success of open nesters in lowland hardwoods (Stauffer 1978). It also is difficult to characterize habitat in detail for some ubiquitous species (cardinal, American redstart, common crow, and Carolina wren). Additionally, reported habitat use of a species varies from locale to locale. For example, the blue-gray gnatcatcher may prefer a close-canopy forest with little understory (Anderson and Shugart 1974) or may be a habitat generalist (Root 1967, James 1971) rose-breasted grosbeaks may nest in flood plain habitats (Stauffer 1978) or in xeric upland forests (Bond 1957).

For many species, however, the foraging guild encompasses the preferred nesting habitat. The yellow warbler (234), common yellowthroat (234), alder flycatcher (235), Louisiana waterthrush (223), fox sparrow (334), Lincoln sparrow (334), and rufous-sided towhee (334) nest in low shrub willow-bushy areas (Graber et al. 1974, Shugart and James 1974). As a tree layer-edge develops, the kingbird (243), black-billed cuckoo (244), parula warbler (244), gray catbird (234), and indigo bunting (344) nest in areas with a variety of life forms including a shrub-stratum, areas of dense saplings, but a poorly-developed canopy. As the forest becomes more xeric or upland in character, nests are found of the bluejay (334), eastern wood pewee (245), brown thrasher (323), yellow-billed cuckoo (244), warbling vireo (244), and northern oriole (344) (Johnston 1947, Johnston and Odum 1956 and others). In tall mature forests, the yellow-throated vireo (254), red-eyed vireo (254), cerulean warbler (254), and yellow-throated warbler (254) nest. Table 3 lists examples of the number of singing males adjusted to individuals per 20 ha for most nesting species found in lowland hardwoods.

BIRD POPULATIONS IN WINTER

Annual residents in lowland hardwoods include the pileated woodpecker, red-bellied woodpecker, yellow-bellied sapsucker, hairy woodpecker, downy woodpecker, white-breasted nuthatch, common flicker, common crow, black-capped chickadee, Carolina chickadee, tufted titmouse, cardinal, and blue jay. Winter woodland residents exclusive of raptors and wading birds, include large flocks of red-winged blackbirds and common grackles which roost in lowland hardwoods, brown creeper, white-throated sparrow, fox sparrow, song sparrow, golden-crowned kinglets, and ruby-crowned kinglets. Some flocks of the pine siskin, purple finch, evening grosbeak, and pine grosbeak also may use lowland forests.

Very little is known of the habitat or energetic requirements of nongame birds in winter. Willson (1970) and Grubb (1975, 1977) have reported the foraging behavior of the white-breasted nuthatch, tufted titmouse, and Carolina chickadee and other species to be influenced by decreased solar radiation, wind velocity, and low temperatures. A pronounced example is the movement of foraging tufted titmice and Carolina chickadees from wooded areas to an old field when temperatures dropped to -20.0 to -29.9 C. The importance of thermal "refuges" such as grape vine thickets or blackberry-hawthorne thickets for these and other species cannot be overemphasized, and additional research on their use is needed. Although some evidence does show that winter movement of song birds, particularly some finches, is influenced by food supply (Bock and Lepthien 1976, iddleton 1977), further research is needed. t is known that artificial feeding (i.e., at nter feeders) can accelerate the onset of eeding (Kallander 1974) to the possible triment of the species, and the overall fect of food supply and habitat condition winter-early spring on the density and stribution of breeding songbirds is not learly known (Knapton and Krebs 1974, lagsvold 1975).

MANAGEMENT RECOMMENDATIONS AND RESEARCH NEEDS

As in the southeast (Dickson 1978) and west (Johnson and Jones 1977), a major threat to avian species is loss of lowland or stream-riverside habitat through conversion to agriculture, stream channelization, and reservoirs. For example, George (1971) pointed out that 8 of 16 birds that no longer breed in Illinois were residents of the Mississippi River flood plain. The passenger pigeon (Ectopistes migratrius) and Carolina parakeet (Conuropsis carolinensis) are extinct species whose decline in part reflects forest clearing (George 1911, McKinney 1960, Walley 1966). The ivory-billed woodpecker (Compephilus principalis), most certainly extinct in the midwest, and the Bachman's warbler (Vernivora bachmanii), an endangered species, may also have declined as lowland forests and swamps disappeared (Chapman 1932, Tanner 1942). On state endangered species lists, 8 birds in Illinois, 3 in Indiana, 7 in Iowa, 9 in Missouri and New York, 6 in Wisconsin, and 3 in Vermont are associated with lowland hardwoods.

In the management of lowland hardwoods, management or compartment unit size decisions should consider the species-area relationship. As Graber and Graber (1976) point out, this concept may be used in the decision-making process for land acquisition and has been useful in Great Britain (Moore and Hooper 1975) in making recommendations for lands under private ownership. However, this concept assumes a large area will include numerous microhabitats (accounting for more species being represented), but this may not be true. Specific requirements, e.g., cane for Swainson's warbler, mud banks for the kingfisher and bank swallow, bluffs (road-cuts) for the rough-winged swallow, and snags for primary excavators (woodpeckers) and secondary holes (titmouse and others) need to be considered. Conner (1978) has pointed out that many trees selected by primary cavity-nesters are infected by a fungal heart rot or other species of fungi. These trees as well as dead trees or snags should be maintained for both potential nest sites and as a foraging stratum for many species as discussed elsewhere in these proceedings. Additionally, area alone does not predict number of avian species present in some habitats or locales (Johnson 1975, Power 1976, Abbott and Grant 1976) and, although promising in management of lowland hardwoods, future empirical evidence is needed.

Under natural conditions, flood activity and soil erosion will create a natural diversity of the species and age classes. Management of lowland hardwoods characteristic of middle and late successional stage by individual or group selection will result in an interspersion of the species and age classes. Clearcutting should be avoided for these successional stages where limited blocks of clearcuts may be beneficial. In contrast to walnut, basswood, and some other species characteristic of mature forests, the commercial value of willow is negligible. Thus, mechanical treatment, or other approaches may be necessary to regenerate brushy thickets characteristic of early successional stages where natural flooding or erosion are ineffective. However, the conversion of large, uneven-aged stands of hardwoods to plantation plantings of cottonwood, sweetgum or sycamore has at least in the southeast reduced avian use and diversity (Wesley et al. 1976) and therefore should be avoided.

Few published reports describe avian habitat needs in north central and northeast lowland hardwoods in contrast to upland or grassland areas (Wiens 1969, Shugart and James 1973, and others). Studies involving both the breeding and non-breeding season similar to Dickson and Noble (1978) would provide a useful basis to approach other information including habitat characteristics important to nest site selection and nest success. Census techniques employed in these studies should clearly recognize behavioral and ecological problems associated with the interpretation of singing of non-breeding and breeding males. There also is a clear need to establish a mathematical framework for these techniques. For example, of available current techniques, Burnham and Anderson (1976:334, 335) point out "Emlen's approach is not mathematical" (Emlen 1971), but improvements in this and other techniques are becoming available (Kovner and Patil 1974, Burnham and Anderson 1976, and others). Additionally, most studies on the effect of forest management practices have emphasized clearcutting rather than individual or group selection cutting (Adams and Barrett 1976, Whitcomb et al. 1977). Because of the importance of those silvicultural practices in management of lowland hardwoods, their effects on breeding and wintering avian populations should be investigated in depth.

Fretwell (1978:3) has recently commented that "the embarrassing thing about being an avian population ecologist in America today is the distance that separates us from our European counterparts." Fretwell's criticism is directed toward the frequent use of the assumption that birds compete for food during the breeding season to support niche diversification and breeding bird diversity studies. As he emphasizes, this assumption is largely untested, and long term studies to support or refute the assumption are lacking in America. Nor do forthcoming long term studies in Europe provide support. Many European workers, however, have long contended that fall-winter food is the factor limiting population size. Yet, in America, few studies have emphasized resource needs (food or habitat) of forest-dwelling birds overwintering in middle or low latitudes. Considering these important information needs, research on resource needs of nongame birds in the non-breeding season should be emphasized in forthcoming years.

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AVIAN COMMUNITIES AND MANAGEMENT GUIDELINES OF THE ASPEN-BIRCH FOREST

Gary N. Back[1]

Abstract.--Avian communities are discussed in relation to succession of the aspen-birch type. Management guidelines are given, but more information on habitats of stenotopic species is required if comprehensive management plans are to be formulated. Avian management and pulpwood management are generally compatible in the aspen-birch type, but some expenditures may be necessary to maximize bird species diversity.

INTRODUCTION

The aspen-birch type is an extensive and economically important forest type. Its importance to wildlife populations has been recognized for ruffed grouse (Gullion and Svoboda 1972) and white-tailed deer (Byelich, Cook, and Blouch 1972), but little is known about its potential for nongame species. The purpose of this paper is to describe selected bird communities occupying various successional stages of the aspen-birch type and present guidelines for the management of these communities. Emphasis is placed on the aspen-birch type in the north central and northeastern forest regions.

Payne and DeGraaf (1975) described the economic value derived from human enjoyment of nongame birds. They predicted an increase in nonconsumptive recreation associated with nongame wildlife. The need exists to develop nongame management plans and to evaluate effects of the present management practices on nongame species.

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THE ASPEN-BIRCH TYPE

The Society of American Foresters (SAF 1954) define the aspen-birch type as stands in which trembling aspen (Populus tremuloides), bigtooth aspen (P. grandidentata), and paper birch (Betula papyrifera) predominate. They occur in various combinations or in pure stands of any one species. Pin cherry (Prunus pensylvanica) and red maple (Acer rubrum) are common associates. In the eastern U.S. and Canada, 22 tree species are associated with trembling aspen, including balsam popular (Populus balsamifera), balsam fir (Abies balsamea), white spruce (Picea glauca), black spruce (P. mariana), and several northern hardwoods (Folwells 1965).

Beaked hazel (Corylus cornuta) and American hazel (C. americana) are common shrubs in the eastern part of the range of this type. Other shrubs frequently associated with the aspen-birch type are mountain maple (Acer spicatum), speckled alder (Alnus rugosa), green alder (A. crispa), raspberry (Rubus idaeus), gooseberries (Ribes spp.), and willows (Salix spp.) (Folwells 1965, Martin 1959).

Three other types, the aspen, paper birch, and gray birch-red maple types, are descriptively or ecologically similar to the aspen-birch type. The aspen type consists of trembling aspen, bigtooth aspen, and balsam poplar occurring singly, in combination with each other, or in combination with associates pin cherry and paper birch. Balsam fir is common in the understory (SAF 1954).

Paper birch occurs in pure stands or is the predominant species in the paper birch type. Associates include trembling and bigtooth aspen, balsam fir, red spruce (Picea rubens), white spruce, white pine (Pinus strobus), yellow birch (Betula lutea), and others. The understory may be coniferous or include tolerant hardwoods (SAF 1954).

The gray birch-red maple type is not dominated by aspen or paper birch, but is ecologically and structurally similar to the previously described types. A mixture of gray birch (Betula populifolia) and red maple predominate, with gray birch usually more numerous. Trembling aspen, bigtooth aspen, pin cherry, yellow birch, and paper birch are common associates (SAF 1954).

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The four types are combined and referred to as the aspen-birch type in the following discussion except where special reference to a particular type is necessary.

The range of the aspen-birch type is shown in Figure 1. The range was determined by combining the range limits of the four major species: trembling aspen, paper birch, balsam popular, and bigtooth aspen. It includes portions of the boreal, northern hardwood-conifer, and eastern deciduous forests (Aldrich 1963). Because of the extent of the range (approximately 110° of longitude and 30° of latitude) the climatic conditions are quite variable. The type is generally found in areas of long, cold winters with long periods of snow cover and summers that are cool and short (Folwells 1965).

The aspen-birch type is found primarily on uplands of glacial till with a high but moving water table (SAF 1954). Trembling aspen and paper birch develop best on well-drained sandy loams but are found on all but the wettest swamps and driest sands (Folwells 1965). The gray birch-red maple type occupies sand plains as well as heavier-soiled uplands and wet stream margins.

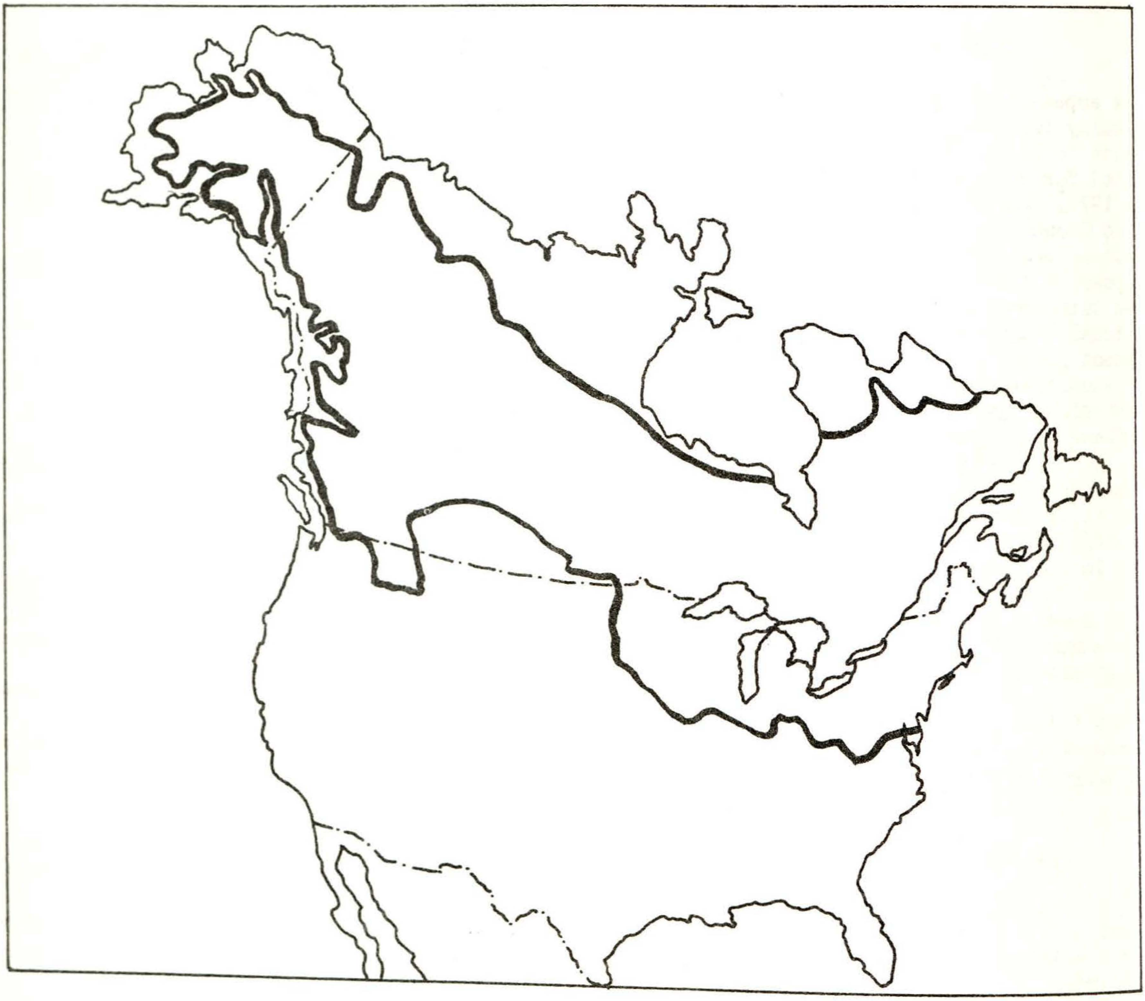

Figure 1.--The range of the aspen-birch type in North America.

SUCCESSIONAL PATTERNS

The aspen-birch type is a relatively short-live pioneer community. Both aspen and paper birch have lightweight seeds[2] which allow long distance dispersal by wind. However, the seeds quickly lose their viability. The seeds of aspen remain viable only two to three weeks under optimum conditions (Moss 1938) and paper birch seeds remain viable for months if the proper moisture conditions are maintained (Joseph 1929). A bare mineral soil is required because the seedling radicle is very delicate and can not penetrate litter (Hutnik 1954). Soil moisture conditions must remain high during the period of germination and root development, as the seedlings quickly succumb to desiccation.

Both species are also capable of vegetative reproduction; root suckering by aspen and stump sprouting by paper birch. The degree of vegetative reproduction depends on a variety of factors of which age and vigor of parent trees, predisturbance stocking, season of disturbance, and degree of canopy destruction are of major importance.

Two natural agents of destruction that were capable of providing suitable conditions for both methods of reproduction in the primeval forests were fire and wind (Cline and Spurr 1942). Heinselman (1973) found that the composition and structure of the presettlement vegetation as well as the vegetation mosaic on the landscape were largely determined by fire for the Boundary Waters Canoe Area in northeastern Minnesota. The aspen-birch type was part of the mosaic. Kittredge (1938) found trembling aspen and paper birch were two of several species with light, windborn seeds or capable of reproduction from underground parts that colonized after fire.

The type which succeeds aspen-birch depends on the nature of the breakdown process, tolerance and stocking level of associate species, and site conditions. Martin (1959) found that in Ontario balsam fir-white spruce succeed aspen-birch after 50-75 years. The spruce and fir are released from the understory as the aspen and birch gradually die out. On xeric sites, northern red oak (Quercus rubra) and bur oak (Q. macrocarpa) replace the aspen-birch (Hansen and Kurmis 1972). On rich, moist sites the beech-birch-maple or maple-basswood type succeed the pioneer type (Stewart and Aldrich 1952, Hansen and Kurmis 1972). In New England, aspen and birch commonly invade abandoned fields along with white pine, which eventually becomes dominant (Cline and Lockhard 1925, Back 1976).

TIMBER MANAGEMENT PRACTICES

The aspen and aspen-birch types account for approximately 35 percent or 17.9 million acres of commercial Lake States forest[3]. Fifty-four percent of the merchantable hardwoods in Canada are aspens (Maini 1972). Aspen and birch together made up 49.2 percent of the total Lake States pulpwood production from roundwood in 1976 (Blyth and Hahn 1978). Paper birch also has value as a veneer quality hardwood in northern New England where it reaches its best development (Folwells 1965).

The silvics of aspen and birch dictate that they should be managed in even-aged stands. Clearcutting to remove merchantable trees followed by elimination of residual stems greater than 1.5 inches (3.8cm) d.b.h. is the basic prescription (Graham, Harrison, and Westell 1963, Marquis, Solomon, and Bjorkbom 1969). The minimum size of the cuts, to be economically attractive, is 10-20 acres (4-8 ha) [3]. The size of the cutting, seedbed preparation, and season of cutting can be altered to favor birch over aspen (Marquis et al. 1969). Intermediate cultural treatments such as cleaning and thinning have been shown to increase growth and yield of aspen (Schlaegel 1972, Hubbard 1972) and paper birch (Marquis et al. 1969). However, economic feasibility requires that the stands have high site index values, potential for veneer or saw quality trees, and are close to the mill (Hubbard 1972).

Prescribed burning following logging has been shown to increase aspen sucker density (Perala 1972) and create favorable seedbed conditions for paper birch and aspen. Although ground fires easily girdle thin-barked paper birch and allow the introduction of wood rotting fungi to fire damaged aspen, the fuel required for crown fires that result in regeneration of the type are not abundant. The shortage of fuel in aspen types prompted Castle and Engle (1972) to suggest that aspen-hardwood types could be used as fuel breaks in pine areas. The conditions required for a high degree of canopy kill in aspen-hardwood types would cause sever fires in other fuel types[4].

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[2] There are approximately 3 million aspen seeds per pound and 1.5 million paper birch seeds per pound (Folwells 1965).

[3] Lundgren, A.L. Economics of aspen management. A paper presented at the joint meeting of Great Lakes Deer Group and the Ruffed Grouse Workshop, Quadna Mt. Lodge, Hill City, MN, Sept. 22, 1970.

BIRD HABITAT ASSOCIATIONS

Breeding Birds

Approximately 116 forest bird species breed in the central and eastern portion of the aspen-birch type. The number of individuals and species vary with several habitat parameters such as habitat patchiness (MacArthur, MacArthur, and Preer 1962, Roth 1976), total foliage volume (Willson 1974), vertical stratification (MacArthur and MacArthur 1961), canopy mixture of hardwoods and conifers (Hooper, Crawford, and Harlow 1973), moisture gradient (Smith 1977), and successional stage (Johnston and Odum 1956, Shugart and James 1973).

For comparative purposes in the following discussion of published literature, the stand development of the aspen-birch type has been divided into three categories: 1) seedling-sapling atage; 2) sapling-pole stage; 3) pole-mature stage.

Seedling-Sapling Stage

The species and density of territorial males reported in six censuses that represent the seedling-sapling stage are given in Table 1. Three species, chestnut-sided warbler (Dendroica pensylvanica), white-throated sparrow (Zonotrichia albicollis), and mourning warbler (Oporornis philadelphia), were present in all six censuses. The same three species and the song sparrow (Melospiza melodia) had the highest densities. The presence of house wrens (Troglodytes aedon) on two of the burned areas may have been due to the availability of cavities in the burned snags (Bergstedt and Niemi 1974). A high density of least flycatchers (Empidonax mimimus) on only one of the burned areas may have been due to a difference in snag density. The 2-year old burn with the high density of least flycatchers had a tree density of 900 per acre (2,220 per ha), of which 90 percent were burned snags (Bergstedt and Niemi 1974). The 3-year old burn had a snag density of 264 per acre (650 per ha) (Niemi 1974a) and a low density of least flycatchers. Yellowthroats (Geothlypis trichas), blackburnian warblers (Dendroica fusca), and rose-breasted grosbeaks (Pheucticus ludovicianus) were found in an island of mature trees within the burned area (Bergstedt and Niemi 1974) and may not be representative of the first development stage.

Of the 36 species recorded in the seedling-sapling stage, 18 species were recorded in only one census. Twenty-four species had maximum densities less than 10 per 100 acres (40 ha). The bird species diversity (BSD) index[5] values were generally low, the highest being 2.50 for the 10-15 year old clearcut.

The dominant tree species of the six census areas was aspen; paper birch was not a major component of any area. The greatest stem density reported was 30,700 aspen suckers per acre (76,000 per ha) on the 3-year old burn (Niemi 1974a). The stands ranged from 3 feet (0.9 m) tall for the 1-year old cut to 10-15 feet (3-4.6 m) for the 10-15 year old clearcut.

Sapling-Pole Stage

Seventeen more bird species were recorded in the sapling-pole stage than in the seedling-sapling stage. Only the ovenbird (Seiurus aurocapillus) and red-eyed vireo (Vireo olivaceus) were recorded in all five censuses (Table 2). Veerys (Hylocichla fuscescens), yellowthroats, and indigo buntings (Passerina cyanea) had higher densities and were recorded in more censuses in the second stage than in the first stage of development. Three species not recorded in the first stage but relatively abundant in the second stage were the black-capped chickadee (Parus atricapillus), catbird (Dumetella carolinensis), and goldfinch (Spinus tristis). The robin (Turdis migratorius) remained about the same density. The white-throated sparrow, chestnut-sided warbler, and song sparrow had decreased densities while the mourning warbler was not recorded in any of the five sapling-pole stage censuses.

The second-growth forest in Vermont, censused two consecutive years by Breault and Farrar (1972) and Farrar (1973), had the greatest BSD value (3.29) and the greatest number of species recorded (36) of the sapling-pole stage. Approximately 50 percent of the tree density was trembling aspen and paper birch and 33 percent was white pine. It was the only census area in which the wood thrush (Hylocichla mustelina) was relatively abundant.

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[4] Sando, R. Burning aspen-hardwood stands. A paper presented at the joint meeting of Great Lakes Deer Group and the Ruffed Grouse Workshop, Quadna Mt. Lodge, Hill City, MN, Sept. 22, 1970.

[5] The bird species diversity index provides a numerical basis for comparing avian communities. It incorporates both the number of species and the abundance of each species present (MacArthur and MacArthur 1961).

Table 1.--Territorial male birds per 100 acres (40 hectares) of six censuses of the seedling-sapling stage.

Species	Stand 1 yr. old clearcut1/	2 yr. old clearcut2/	2 yr. old burn3/	2 yr. old burn4/	3 yr. old burn5/	10-15 yr stand6/	Average 7/
Chestnut-sided Warbler	11	24	40	58	42	33	34.7
White-throated Sparrow	32	49	36	20	27	33	32.8
Mourning Warbler	22	54	7	41	27	33	30.7
Song Sparrow	32	32	26			13	25.8
Yellowthroat	11	16		3		20	12.5
Robin	16	5			3	7	7.8
Common Snipe	5	11					
Woodcock	5	5					
Common Flicker		5	3		3		
Red-eyed Vireo			20	10	3		
House Wren			33	17		13	
Brown Thrasher			3		3		
Blue Jay				7	3	7	
Least Flycatcher				37	3		
Hairy Woodpecker				3	3		
Chipping Sparrow				3	6		
Veery				3		7	
Hermit Thrush					3	7	
Swamp Sparrow		5					
Common Grackle			13				
Yellow-bellied Sapsucker				7			
Ruffed Grouse				3			
Blackburnian Warbler				3			
Ovenbird				3			
Rose-breasted Grosbeak				7			
Downy Woodpecker					3		
Black-backed Three-toed Woodpecker					3		
Dark-eyed Junco					3		
Cedar Waxwing					3		
Indigo Bunting					3		
Common Nighthawk					3		
Nashville Warbler						13	
Black and White Warbler						7	
American Redstart						7	
Alder Flycatcher						7	
Red-breasted Nuthatch						7	
Total Density	134	211	181	225	144	214	184.8

1/Minnesota, Niemi 1974b.

2/Minnesota, Niemi 1975.

3/Minnesota, Bergstedt 1973.

4/Minnesota, Bergstedt and Niemi 1974.

5/Minnesota, Niemi 1974a.

6/Minnesota, Doran and Todd 1976.

7/The average was calculated only if a speices occurred in four or more censuses.

Table 2.--Territorial male birds per 100 acres (40 hectares) of five censuses of the sapling-pole stage.

Species	Stand Location					
	Maine1/	N. Dakota2/	Vermont3/	Vermont4/	Saskatchewan5/	Average6/
Ovenbird	20	38	20	8	32	23.6
Red-eyed Vireo	10	55	19	12	13	21.8
Veery	10	65	8	6		22.3
Black-capped Chickadee		10	13	8	2	8.3
Robin	10	5	6	4		6.3
Yellowthroat	45		10	8		21.0
White-throated Sparrow	25		15	16		18.7
Chestnut-sided Warbler	25		19	8		17.3
Catbird	25		17	6		16.0
American Redstart	30		4	6		13.3
American Goldfinch	15	15	2			10.7
Black and White Warbler			12	8	5	8.3
Indigo Bunting	20		2	2		8.0
Downy Woodpecker	15	3		2		6.7
Great Crested Flycatcher		10	4	6		6.7
Eastern Phoebe	15		2	2		6.3
Ruffed Grouse	10		4	2		5.3
Yellow Warbler	40	10				
Song Sparrow	15			2		
House Wren		20	1			
Wood Thrush			22	8		
Blue Jay			12	8		
Rufous-sided Towhee			12	4		
Blackburnian Warbler			8	6		
Brown Thrasher			6	4		
Eastern Wood Peewee			4	2		
Brown Creeper			4	6		
Yellow-rumped Warbler			4	2		
Scarlet Tanager			4	2		
Common Crow			2	2		
Cardinal			2	2		
Rose-breasted Grosbeak			2	2		
Field Sparrow			2	8		
Magnolia Warbler			4	2	1	
Others	10	114	13	12	38	
Total Density	340	345	259	174	91	241.8

1/Twenty-one year old birch stand, Townsend 1968.

2/Pole stage aspen stand, Clink 1969.

3/Pole stage mixed white pine-paper birch-trembling aspen, Breault and Farrar 1972.

4/Pole stage mixed white pine-paper birch-trembling aspen, Farrar 1973.

5/Young aspen stand, Erskine 1973a.

6/The average was calculated only if a species occurred in three or more censuses.

The aspen forest in Saskatchewan censused by Erskine (1973a) regenerated after a fire. The stand was approximately 30 years old and dominated by trembling aspen. The area had the lowest BSD value (1.64), the least number of species (10), and the lowest density of territorial males (91 per 100 acres) of the five census areas.

Pole-Mature Stage

The ovenbird, red-eyed vireo, and least flycatcher were recorded in all seven censuses of the mature aspen-birch type (Table 3). Mourning warblers which were not recorded in the sapling-pole stage were recorded in the pole-mature stage. The ovenbird, least flycatcher, and Swainson's thrush (Hylocichla ustulata) were more abundant in this stage than either of the first two stages. The red-eyed vireo, veery, black and white warbler, robin, and redstart (Setophaga ruticilla) had about the same abundance as in the sapling-pole stage. Chestnut-sided warblers, white-throated sparrows, black-capped chickadees, yellowthroats, catbirds, and goldfinches all decreased in abundance in the pole-mature stage.

The censuses of the mature stage were scattered from New Brunswick to Saskatchewan. The dominant tree species of four of the censuses were trembling aspen, balsam poplar, and paper birch. Balsam fir and white spruce were the major subdominants (Erskine 1969, 1970, 1971, Price and Speirs 1971).

The greatest BSD value (3.12) and number of species recorded (28) for the mature stage occurred on a Minnesota site dominated by paper birch and red maple (Doran and Todd 1976). Another forest dominated by paper birch in Saskatchewan, however, had the lowest BSD (1.79) and fewest number of species (11) (Erskine 1973b).

The stand censused in Manitoba (Erskine 1972) was the only mature stand in which conifer species were not present. Balsam poplar, trembling aspen, and paper birch were the major canopy species. The understory was also deciduous. The redstart had an estimated territorial male density of 80 per 100 acres, which was more than double the density for any other census of all stages of development.

Successional Trends

The general pattern of bird species diversity through succession is for increased BSD with increased ecological age (Shugart, Anderson, and Strand 1975). The BSD values of the censuses cited above did not follow this general trend. The BSD values tended to increase from the first to the second stage of stand development, but were quite variable in the third stage of development (Table 4). Both the highest and lowest BSD values were obtained from censuses of the sapling-pole stage.

Willson (1974) found the greatest increase of bird species occurred with the initial development of the tree layer and only a small increase as the tree layer developed further. Seventeen more species were recorded on the sapling-pole stage census areas than on the seedling-sapling stage areas. The addition of only three species on the mature stage areas also agrees with her findings. The average number of species per census of the three development stages were 12.8, 22.3, and 18.4.

As expected, changes in relative abundance and species composition of the avian community occurred as the age of the stands increased. Figure 2 shows some of the patterns exhibited. In general, the species which were abundant in the first stage decreased as the stands developed and the species which were abundant in the mature stands were infrequent in the seedling-sapling stage. The chestnut-sided warbler, white-throated sparrow, mourning warbler, song sparrow, and yellowthroat were the characteristic species of the seedling-sapling stage. The pole-mature stage was dominated by the ovenbird, red-eyed vireo, least flycatcher, and veery. The intermediate stage had a mixture of the dominant species of both the first and third stages. Qualitative studies by Adams (1908), Stewart and Aldrich (1952), and Beals (1960) reported similar findings.

Winter Birds

Relatively few birds were found in the aspen-birch type in the winter. Six censuses recorded only 14 species (Wunderle and Schemnitz 1969, Goulden 1973, Kienzler 1973, 1974, Park and Goulden 1974, Burgason 1975). The black-capped chickadee and ruffed grouse (Bonasa umbellus) were recorded in all six censuses and the downy (Dendrocopos pubescens) and hairy woodpeckers (D. villosus) were recorded in five censuses. All other species were found only in 1-3 censuses. The black-capped chickadee had the highest density; 23 per 100 acres in one census.

Table 3.--Territorial male birds per 100 acres (40 hectares) of seven censuses of the pole-mature stage.

Species	New Brunswick1/	Minn.2/	Ontario 3/	Ontario 4/	Ontario 5/	Manitoba 6/	Saskatchewan 7/	Average 8/
	Stand Location							
Ovenbird	38	22	56	25	20	23	47	33.0
Red-eyed Vireo	11	27	60	10	10	29	51	28.3
Least Flycatcher	5	27	76	32	33	8	15	28.0
Veery	13	16	32	3	4	17		14.2
Swainson's Thrush	7	5	2	10	6	6		6.0
Black and White Warbler		5	12	4	1	14		7.2
American Redstart	11			2	2	80		23.8
Mourning Warbler		11	10	10	10			10.3
Chestnut-Sided Warbler		22		2	4	1		7.3
Rose-breasted Grosbeak	5	11	8			3	2	5.8
White-throated Sparrow	4	5		6	8			5.8
Hermit Thrush	2	11	4					
Magnolia Warbler	2	5			1			
Canada Warbler		22	4			5		
Black-trhoated Green Warbler		5	16				15	
Winter Wren		5		2	4			
Ruffed Grouse			4	2	2			
Philadelphia Vireo				21	25	9		
Bay-breasted Warbler				2	2		5	
Red-breasted Nuthatch	4	11						
Blackburnian Warbler		5	12					
Purple Finch		5	4					
Downy Woodpecker		5				1		
Great Crested Flycatcher			12			5		
Woodcock				2	1			
Tennessee Warbler						2	10	
Others	16	46	52	0	3	7	11	
Total Density	132	282	366	138	143	211	156	204.0

1/Thirty-forty year old aspen birch stand, Erskine 1969.

2/Thirty-forty year old paper birch-red maple stand, Doran and Todd 1976.

3/Mature aspen-birch forest, Price and Speirs 1971.

4/Mature poplar forest, Erskine 1970.

5/Mature poplar forest, Erskine 1971.

6/Mature aspen-birch forest, Erskine 1972.

7/Mature birch-aspen forest, Erskine 1973b.

8/The average was calculated only if a species occurred in four or more censuses.

Table 4.--Bird species diversity values (BSD) and total number of species recorded for three categories of stand development.

Stage of Development	BSD[1]	Total Number of Species	Source
Seedling-sapling Stage			
1 year old clearcut	1.90	8	Niemi 1974b.
2 year old clearcut	2.03	11	Niemi 1975.
2 year old burn	1.94	9	Bergstedt 1973.
2 year old burn	2.16	16	Bergstedt and Niemi 1974.
3 year old burn	2.26	18	Niemi 1974a.
10-15 year old clearcut	2.50	15	Doran and Todd 1976.
Sapling-pole Stage			
21 year old stand	2.71	17	Townsend 1968.
Pole stage stand	2.22	14	Clink 1969.
Pole stage stand	3.29	36	Breault and Farrar 1972.
Pole stage stand	3.07	35	Farrar 1973.
Approx. 30 year old stand	1.64	10	Erskine 1973a.
Pole-mature Stage			
30-40 year old stand	2.32	14	Erskine 1969.
30-40 year old stand	3.12	28	Doran and Todd 1976.
Mature stand	2.61	26	Price and Speirs 1971.
Mature stand	2.30	16	Erskine 1970.
Mature stand	2.41	19	Erskine 1971.
Mature stand	2.08	15	Erskine 1972.
Mature stand	1.79	11	Erskine 1973b.

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[1] Calculated from the Shannon information formula, BSD = $H' = -\Sigma p_i \ln p_i$, where p_i = the proportion of species (i) of all birds in a census (MacArthur and MacArthur 1961).

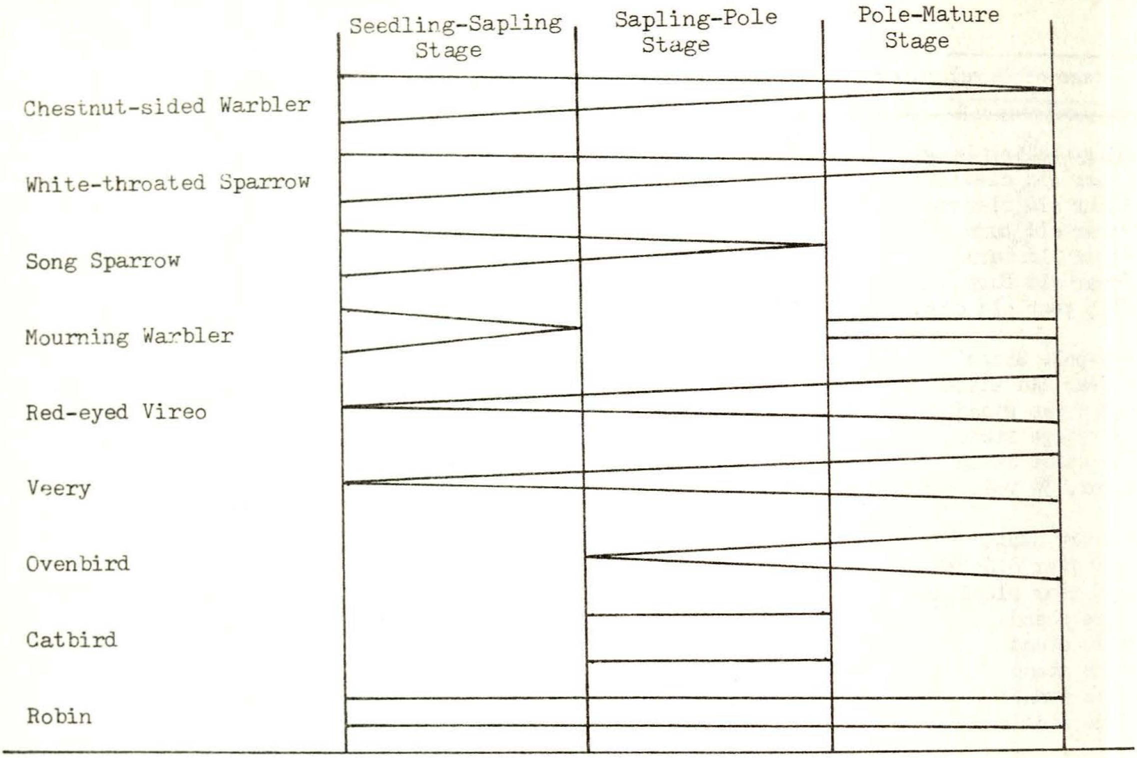

Figure 2.--Changes in species relative abundance in relation to ecological stand age.

MANAGEMENT GUIDELINES

The recent movement to develop management guidelines for nongame species has emphasized the concept of community management versus the traditional single species concept. This emphasis is to be lauded. However, a species exists only where the habitat provides its specific requirements. Some species have a wide range of tolerance for specific factors (eurytopic species) while others have a restricted range of tolerance (stenotopic species). It is necessary that the stenotopic species and their specific requirements be identified before the management prescriptions are formulated. Trade-offs in species diversity may be necessary to prevent the loss of stenotopic species.

It is obvious from the 18 censuses summarized in Tables 1-3 that only 16 of the 78 species recorded were abundant in one or more stages of stand development. Of the remaining 62 species, there are probably some for which the aspen-birch type in any form would be marginal habitat. Yellow-rumped (Dendroica coronata) and blackburnian warblers are examples of this category. They appear in low density in the aspen-birch type when coniferous species are present in the understory or canopy, but they are considered members of the spruce-fir avian community. For other species, presence of some special factor can be the difference between abundance and scarcity or even absence. Balda (1975) found the abundance and diversity of cavity nesting birds increased with increased availability of snags. The house wren apparently responded to the availability of cavities in snags on one census area (Bergstedt and Niemi 1974). Erskine (1972) was of the opinion that the dense deciduous understory was a factor in the extremely high density of redstarts in one Manitoba census. Other factors may have been responsible for high densities of yellow warblers (Dendorica petechia) and indigo buntings on one census area (Townsend 1968) as they were infrequent on the other census areas. Until the specific requirements for all species are identified, only basic guidelines of management can be formulated.

Maintenance of the aspen-birch type requires even-aged management in the form of seedtree or clearcutting prescriptions. In areas where a pulpwood market exists, avian management and pulpwood management are compatible. The stands should be cut on a 40-60 year rotation, depending on site quality. The loss of vigor of parent trees after age 60 reduces their suckering and stump sprouting ability (Folwells 1965), resulting in possible type conversion to tolerant hardwoods or conifers. Slash removal is not necessary in a commercial cutting and may not be desirable for avian management. The larvae and adults of wood-boring beetles that attack slash are fed upon by several species of woodpeckers (Martin, Zim, and Nelson 1961, Conner and Crawford 1974). Prescribed burning of the felled timber can be used to regenerate the type where commercial outlets are not available. However, aspen fuels need to be cured before they can sustain a hot fire (Perala 1972).

The optimum size of the cuttings has not been determined. The minimum size of 10-20 acres needed to make pulpwood operations economically feasible is probably compatible with avian management. Shape of the cut should be considered for areas over 50 acres to provide a high ratio of edge to area. Rectangular strips or irregular shaped cuts create more edge than square cuts.

Several practices can be used to increase species diversity of an area. Cuttings should be spaced temporally to create several age classes on a management unit. Cuttings at 10-15 year intervals with a 40-60 year rotation would result in four age classes. The spacial arrangement of the cuttings should also be considered. "Snag management" as previously mentioned, can increase diversity. Special habitats within a stand (e.g. riparian vegetation) should also be maintained if maximum species diversity is an objective. These additional practices may reduce pulpwood yields or require some additional expenses.

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OAK FOREST BIRD COMMUNITIES

John R. Probst[1]

Abstract.--Oak forests represent the largest forest type in the United States. The density and diversity of avian species in oak forests are dependent on habitat factors such as vegetation structure and successional stage. Therefore, they are greatly affected by management considerations such as cutting, thinning, rotation age, stand size, and tree species composition. The species number and population sizes of breeding birds and winter birds are contrasted.

The Appalachian Oak and/or Oak-Hickory types form the largest forest type in the United States, representing about 125 million acres. Eastern hardwoods compose more than half the commerical timber land in the United States, and the Oak and Oak-Pine types combined total about 147 million acres, or 60 percent of the eastern commercial forest. This acreage exceeds the total commercial timber area of all western forest types combined (U.S. Department of Agriculture, Forest Service 1977). Because this forest type spans a wide range of altitudes, latitudes, and longitudes, a number of bird species are associated with it as breeding, migrant, or wintering birds. In the nesting season, from 90 to 100 different bird species can be found in northeast or north-central oak forests, clearcuts, and edges. The avifauna of southern Oak-Hickory and Oak-Pine forests has been covered by Evans (1978).

DESCRIPTION AND EXTENT OF THE TYPE

The oak forests of the northeast and north-central United States are more concentrated in the northern Appalachian region, extending north to New York and southeastern New England, and west to Ohio and the Cumberland Plateau. Oak forests are common in the Piedmont of the Mid-Atlantic States, and the oak-hickory type forms a mosaic with other vegetation types in much of Ohio, Indiana, Illinois, and southern Michigan. In addition, oak stands are found at the border of the northern hardwoods region in Minnesota, Wisconsin, and Michigan, and oaks can be the major seral species in both the mixed mesophytic area and the northern hardwoods type. Last, oaks are the major tree species in the prairie borders (Minnesota, Wisconsin, Illinois, and Iowa) in oak savannas or in fairly closed stands that expand and contract with temporary climatic conditions and fire.

Oak Forest Acreages for Selected States
(U.S. Department of Agriculture,
Forest Service 1977)

		(millions of acres)
1.	Missouri	11.46
2.	Virginia	10.33
3.	Tennessee	9.71
4.	Kentucky	9.27
5.	Pennsylvania	7.98
6.	West Virginia	7.50
7.	North Carolina	6.36
8.	Ohio	3.00
9.	Wisconsin	2.76
10.	Indiana	2.42
11.	Illinois	2.26
12.	Michigan	2.12
13.	Maryland	1.45
14.	Connecticut	1.39
15.	New York	1.36
16.	Minnesota	1.33
17.	Massachusetts	1.26
18.	Iowa	1.25
19.	New Jersey	.81
20.	New Hampshire	.62
21.	Maine	.29
22.	Vermont	.11
23.	Delaware	.08

The most common oak species are northern red *(Quercus rubra)*, white *(Q. alba)*, black *(Q. velutina)*, scarlet *(Q. coccinea)*, and chestnut *(Q. prinus)*. On medium sites hickories, such as pignut *(Carya glabra)* or mockernut *(C. tomentosa)*, may form a minor part of the canopy, and on moist sites yellow-poplar *(Liriodendron tulipifera)*, shagbark hickory *(C. ovata)*, and various northern hardwood species may be present. On steep slopes and ridge tops, pitch pine *(Pinus rigida)* may occur regularly as a minor component. Red maple *(Acer rubrum)* and white ash *(Fraxinus*

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americana) usually fill in openings in the canopy and can often be major constituents of the canopy or understory. Such openings can result from natural causes, or be caused by selective cuttings, or thinning.

In southern Michigan, northern pin oak *(Q. ellipsoidalis)* can be important, and bur oak *(Q. macrocarpa)* can be dominant in southern Minnesota and the prairie borders. Oak forests in southern New England may be heavily mixed with white pine *(P. strobus)* as well as beech *(Fagus grandifolia)* and maple.

Tree species of oak forests that are usually of subordinate status include flowering dogwood *(Cornus florida)*, sassafras *(Sassafras albidum)*, black birch *(Betula lenta)*, and black gum *(Nyssa sylvatica)*. Choke cherry *(Prunus virginiana)*, hop hornbeam *(Ostrya virginiana)*, black cherry *(P. serotina)*, and redbud *(Circis canadensis)* are less common on the poorer sites. The shrub layer of the drier sites is usually dominated by ericaceous shrubs such as laurel, blueberries, huckleberries, and sweet fern *(Myrica asplenifolia)*. Fair sites may have witch hazel *(Hamamelis virginiana)*, azaleas, various ferns, club mosses, and striped maple *(Acer pensylvanicum)*. The better oak stands may contain such plants as green briars, viburnums, poison ivy *(Rhus radicans)*, and spicebush *(Lindera benzoin)*.

The most distinguishing characteristic about the herb layer in oak forests is its poor development. Tree seedlings and blueberries often form the predominant forest floor cover, but common herbs are wild sarsaparilla *(Aralia nudicaulis)*, may apple *(Podophyllum peltatum)*, teaberry *(Gaultheria procumbens)*, asters, bloodroot *(Sanguinaria canadensis)*, and trilliums.

Major tree species in old-field succession in the oak forest region include hawthorne, aspens, black locust *(Robinia pseudo-acacia)*, red maple, black cherry, and choke cherry. In oak barrens that result from fire, scrub oak *(Q. ilicifolia)* may form nearly pure, almost impenetrable stands. In more mesic situations, shrubs such as dogwood may be the earliest woody pioneers and may be associated with American elm *(Ulmus americana)* and black walnut *(Juglans nigra)* along with the more mesic oak species. On dry sites such as slopes or abandoned upland pastures, conifers such as red cedar *(Juniperus virginiana)*, pitch pine, and scrub pine *(Pinus virginiana)* are well represented. The oaks themselves tend to seed in from the edges and are rarely pioneers in abandoned fields because the acorns need to be spread by animals for longer dispersal distances.

The oak type grades into the oak-pine type in drier situations and into mixed hardwoods (mixed mesophytic) in moister areas. Intermediate stands on mesic sites contain greater proportions of red oak, yellow poplar, American basswood *(Tilia americana)*, beech, sugar maple *(Acer saccharum)*, white ash, and hickories. Compared with other hardwood forest types, oak woodlands typically have simple vegetation structure and often contain few plant species.

BREEDING BIRD COMMUNITIES

Species Composition

Blue Jays and Brown-headed Cowbirds are species of generalized habitat requirements that are found in almost every stand, regardless of age or structure. However, most birds require a specific type of habitat. The breeding bird species of oak forests can be conveniently grouped into five categories, each of which responds to a different habitat (table 1).

(1) The bark foragers nest in cavities of dead or dying trees, and drill, chip, or glean for their food on the tree trunks or large branches. Many other secondary cavity-nesting birds are ultimately dependent on those bark foragers that excavate cavities. Some examples of birds in this group are Flicker, White-breasted Nuthatch, Downy Woodpecker, and Hairy Woodpecker.

(2) The active gleaners that feed in the tree canopy. Some examples of birds in this group are Chickadee, Tufted Titmouse, and Red-eyed Vireo.

(3) The pursuers also feed in the tree canopy but follow a sit-and-wait strategy. Flycatchers and tanagers are the common pursuers in oak forests.

(4) The ground species are associated with the shrub and sapling layers, but not all members of this group use the understory for their feeding activities--Thrushes, Rufous-sided Towhees and Ovenbirds forage on the ground and use the shrubs for cover and nest sites.

(5) Warblers are the main species associated with a dense growth of saplings and small trees beneath the canopy. Other birds, such as Parids, can become more abundant under these conditions than they would be in forests with a tree layer of simple structure. Because most Appalachian Oak forests are too dry and open for a dense, continuous column of foliage to develop, woodland warblers are less common than they are in more mesic forest types, such as

Table 1.--*Consuming biomass of the forest feeding groups (adapted from Probst 1976)*

(In grams per 40 hectares)

Plot No.	Bark	Gleaners	Pursuers	Ground	Warblers	Misc.	Total
Young-1	--	219	178	1,321	44	459	1,762
Young-2	--	553	100	602	--	403	1,255
Intermed.-1		432	583	10	--	403	1,600
Intermed.-2	556	273	618	360	--	457	1,807
Intermed.-3	771	910	452	--	--	476	2,133
Mature-1	940	320	450	--	--	403	1,710
Mature-2	637	160	716	--	--	678	1,513
Mature-3	1,124	384	446	--	--	364	1,954
Mature-4	956	264	864	66	--	663	2,150
Complex Can.	340	569	883	2,702	--	221	4,494
Complex Can.	454	770	375	939	--	559	2,538
Forest-32	1,150	224	713	1,446	--	301	3,533
Forest-33	839	629	963	1,387	--	325	3,818
Forest-34	673	751	342	361	--	476	2,128
Forest-35	521	164	676	1,354	--	831	2,715
Forest-36	388	236	545	1,453	95	442	2,717
Forest-37	41	634	473	1,304	216	--	2,668
Forest-38	621	251	700	1,407	161	658	3,140
Forest-39	418	568	308	2,143	470	400	3,907
Average	579	437	547	887	52	448	2,502

Mixed Hardwoods. When present, Black-throated Green Warbler, Black and White Warbler, and Chestnut-sided Warbler are the most regular species, but in the southern parts of the oak forest region, Hooded Warbler, Kentucky Warbler, and Yellow-throated Warbler can be important in stands of suitable vegetation structure.

There is a group of species that favors open, mature stands with large, spreading tree crowns. Such conditions are most common in floodplain forests, but can also occur in other forests with incomplete timber harvesting or heavy natural tree mortality. In forests of this structure Yellow-throated Vireos, Blue-gray Gnatcatchers, and rarely, Cerulean Warblers may be found.

As a young oak forest matures, the relative importance of the avian groups discussed above changes. Shrub cover diminishes with canopy closure and eliminates some ground feeders and foliage gleaners that require dense growth. The maturation of the tree layer makes possible the availability of the bark-foraging niches, and the openings in the canopy can be used by pursuers. If management or historical factors such as fire or disease allow for an understory and complex canopy to develop, ground feeders will be common and warblers and other foliage gleaners should also be present. However, the lower age distribution of trees in such stands are less favorable for bark-foragers than forests with more large trees.

Breeding bird censuses conducted in 16 upland oak forests with widely different structures showed that the following bird species occur in **most types of forests** (adapted from Probst 1976):

Species	*Frequency* **(percent)**
Red-eyed Vireo	100
Downy Woodpecker	93
Scarlet Tanager	93
Cowbird	93
Wood Pewee	87
Crested Flycatcher	87
Blue Jay	80
Flicker	80
White-breasted Nuthatch	80
Parid	67
Additional Bark Feeder	40

The first nine species occurred in at least 80 percent of the stands examined. The most frequent additions or substitutions to the basic census were Parids and additional bark feeders. This indicates that forest bird communities are formed by an accumulation of rarer species combined with this more constant group.

The bird species of open habitats in the oak forest region are similar to those in many other forest types. Species of young seres tend to be widespread, and many are found in several biomes. Such wide distributions are rare among climax bird species (Pitelka 1941) This pattern may be a result of the scarcity of secondary habitats. As succession progresse the loss of grasses and forbs decreases the opportunities for seed- and plant-eating birds, while the addition of shrubs and trees provides new niches for primarily insectivorous species.

The red-winged Blackbird and Field Sparrow are overwhelming dominants in the open fields and shrublands, respectively. These two species typically have densities exceeding those for all other species in the community combined. Other important open-field species are Eastern Meadowlarks and Grasshopper Sparrows. In the shrublands, subdominant species include the Yellowthroat, Rufous-sided Towhee, Indigo Bunting, Goldfinch, Song Sparrow, Chipping Sparrow, and Golden-winged Warbler.

Avian Diversity and Density

At the level of the forest stand, avian diversity is strongly influenced by the vertical complexity of the vegetation (Karr and Roth 1971, MacArthur and MacArthur 1961, Probst 1976, Willson 1974) and the amount of patchiness or horizontal heterogeneity (Balda 1975, Roth 1976). The number of species increases with the size of the area sampled, but levels off rapidly in uniform stands. The number of bird species clearly increases with the number of habitat types, a factor strongly affected by climate and topography. The turnover in species per unit of habitat change is also an important factor. All of the above are determinants of the avian diversity of a region or large group of management units.

The following discussion of avian density and diversity is based on census data published in *AMERICAN BIRDS* and on data from a study I conducted in Central Pennsylvania (Probst 1976). The Pennsylvania information was obtained at 39 study plots--7 fields or grasslands, 6 shrublands or old fields, 1 open shrub thicket, 6 clearcut or regeneration stands, and 19 forest stands.

The number of breeding birds in oak forest census plots ranges from 9 to 29 species. The estimated number of territorial males per 40 ha ranges from 65 to 390. The average values for 36 oak census plots are 21.2 species and 222 males/40 ha. Mesic stands can have higher populations; mixed hardwood stands range as high as 413/40 ha (average = 247) with a maximum of 66 species (average = 26.3). Density and diversity of breeding birds generally increases with plant succession (Johnston and Odum 1956, Shugart and James 1973, Shugart *et al.* 1975). Consequently, it is often possible to predict avian density and diversity from estimates of total plant cover (Karr and Roth 1971, Willson 1974, Probst 1976). However, at least in the oak forest region, young seres may overlap with forest stands in their values for avian density and diversity (tables 2 and 3). For example, the densities of birds in shrublands and clearcuts are usually higher than those of dry upland forests.

Table 2.--*Avian diversity of oak forest seres*

Habitat-group	Plots	Equally common species[1]	Species	Equatability[2]
		- - - - - *Number* - - - - -		
Field	7	3.7-4.5	5-8	0.46-0.75
Shrub				
Open	1	6.3	9	.70
Woods	2	2.6-2.9	3	.87-.92
Simple canopy (narrow age range)				
Young	2	5.6	7	.80
Intermediate	3	6.5-8.8	8-11	.72-.81
Mature	4	7.6-9.1	9-11	.73-.85
Complex canopy (wide age range)	2	7.4-9.3	13	.57-.71
Complex forest (multi-layered)	8	7.7-15.0	11-20	.59-.92
Shrubland	6	5.2-11.6	9-18	.48-.81
Clearcut	4	8.7-11.2	14-16	.60-.75

[1] Calculated as $2^{-\Sigma p_i \log_2 p_i}$, where p_i is the proportion of each species.

[2] Number of equally common species divided by the actual number of species.

Table 3.--*Avian abundance of oak forest seres*

Habitat-group	Plots	Birds per 40 ha	Mean abundance per species
		- - - - *Number* - - - -	
Field	7	54-80	9.1-14.3
Shrub			
Open	1	181	20.1
Woods	2	59-66	20-22
Simple canopy (narrow age range)			
Young	2	37-52	5.3-7.4
Intermediate	3	65-106	5.9-11.8
Mature	4	72-89	6.5-8.9
Complex canopy (wide age range)	2	131-156	10.1-12.0
Complex forest (multi-layered)	8	102-188	7.8-12.9
Shrubland	6	132-270	8.9-15.9
Clearcut	4	296-349	20.8-23.3

Predictions of bird species diversity by total coverage show a leveling off somewhere in the high range of values characteristic of forested habitats, so estimators that account for the distribution of foliage are often used. MacArthur and MacArthur (1961) found that Bird Species Diversity (BSD) for a broad range of habitats could be predicted from a measure called Foliage Height Diversity (FHD), an average of the logarithms of the *proportions* of foliage in three height intervals. Although this method underlines the importance of habitat complexity to avian diversity, it has a number of faults (Probst 1976). In addition to being an unnecessary abstraction, the FHD predictor does not allow for differential contributions by the natural layers (structural forms) to the vegetation, especially in plots with a single layer or life form. It also does not account for the absolute amount of foliage in a layer or the total of all layers, and does not register site variations in productivity. As a result, this predictor lacks generality and often cannot be used to compare habitat types as broad as all forest stands within a locality (Probst 1976, Willson 1974). It is more informative to examine the differential contribution of the herb, shrub, and tree layers to avian diversity (tables 2 and 3). When this is done, it can be seen that fields (grasslands) have from 5 to 8 species, but the mature tree layer (simple canopy) in oak forests has from 9 to 11 species. An open scrub oak barren with little herb cover approximates a shrub monolayer and has an intermediate number (9) of species. Thus, the fields show the lowest bird diversity of all habitat groups and simple forests have diversities in the range of more complex open habitats. Complex forests have a higher average diversity than simple canopies, and clearcuts have a slightly higher average than shrublands.

Each layer or structural form of the forest adds to avian diversity, and the amount of cover of each layer also adds to the number of species up to a certain plateau after which the number of bird species remains constant. However, differences in bird diversity are best predicted using only shrub and sapling cover, because in most practical field situations the herb and tree layers are already in the plateau region.

Ground-feeders, shrub-foragers, and bark-foragers can be estimated by shrub-sapling cover. However, it is difficult to predict the density or biomass of the canopy birds by either plant coverage, volume, or conic surface estimates (Probst 1976, Willson 1974). Tree conic surface is linearly related to bark surface area and leaf surface area (Whittaker and Woodwell 1967) and has the potential for simultaneously predicting both bark-feeders and canopy insectivores.

Much of the constancy in the avian density and diversity of the forest canopy can be explained by compensatory changes in the composition of the forest avifauna with changes in age or structure of woodlands. Substantial changes in composition usually do not significantly alter the total species count (fig. 1). Major changes in composition occur when a forest matures (loss of ground species, addition of bark-feeders), when shrubs are added (addition of ground birds), and when a simple forest is contrasted with a complex forest (addition of warblers and thrushes, and the eventual loss of a pursuer and some bark species). In forest stands, great changes in structure cause predictable alternations in avian composition but surprisingly small differences in bird diversity.

Winter Birds of Oak Forests

A large portion of the summer avifauna of the oak forest region migrates to the southern United States or Central and South America in winter. Christmas Bird Counts conducted on a standard 458 km^2 area commonly show land bird counts of from 8 to 14 species (Tramer 1974).

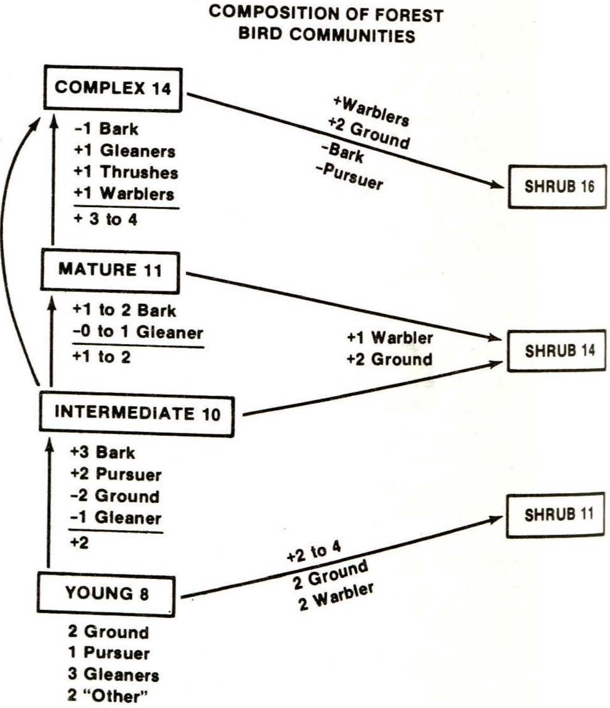

Figure 1.--*Vegetation changes alter the importance of various bird feeding groups, but these changes are often offsetting. The presence of shrubs has a significant positive effect on total species number. The same may be true to a lesser extent for added canopy complexity. The third net increase involves the maturation of the canopy.*

The average number of bird species found in oak forests in the winter is 9 (Winter Bird Population Studies, *AMERICAN BIRDS*). The number of species ranges from 3 or 4 to 16 (Probst and Pearson, unpublished). The average number of species from these winter counts represents less than half of those for oak breeding bird censuses. The number of individuals per 40 ha for the winter counts ranges from 8 (Minnesota) to 140 (Virginia) with an average of 69.4. This is less than a third of the density for breeding bird censuses in the same forest type. By contrast, bottomland hardwoods in Louisiana may have twice as many birds in winter as are present in the summer (Dickson 1978).

Obviously, the oak forest winter avifauna is limited directly or indirectly by climate. Severe temperatures place heavy energy demands on birds at a time when food and cover is minimal. Continuous snow cover eliminates most ground-feeding species such as Common Grackles, Carolina Wrens, and many finches, which are numerous in the southeastern United States during the winter. Insectivores, such as vireos and warblers, also winter south of most of the oak forests. The Yellow-rumped Warbler is usually the only winter warbler to be found in the regions where oak forests are the dominant forest type.

The insectivores that are year-round residents such as Parids or Woodpeckers specialize on arthropods that have over-wintering forms in the crevices of bark or branches. It has been suggested that mixed hardwood-conifer forests may provide better winter habitat for birds (Evans 1978). Few tree species in oak forests retain usable seeds in the winter, as do the birches and conifers of the Northern Hardwood forests. Consequently, stands that contain pine or hardwoods such as yellow poplar or white ash may have higher winter bird populations than pure oak stands.

Bird species that forage in shrubs or on the ground are often found in edges, old fields, or forest openings during the winter because these habitats provide more cover and food (seed-bearing grasses and herbs and fruit-bearing shrubs). In old fields where conifers are important seral species, bird populations might be higher but data are scarce. Winter bird populations may be augmented by irregular invasions of northern finches (crossbills, grosbeaks, and redpolls) in some years. Because most of these species are normally found in boreal or mixed coniferous forests, when found in oak forests they are usually in stands with some mix of conifers or seed-bearing hardwoods.

For almost all bird species, populations are generally higher in valleys or lowlands than on ridges and mountains. This is even true for high elevation stands with a good conifer component. The low density of winter bird populations in highlands is probably related to the short growing season, low productivity, and rigorous winter climate of the highlands.

The most regular or abundant winter bird species of oak forests are the Black-capped Chickadee, White-breasted Nuthatch, Dark-eyed Junco, Golden-crowned Kinglet, Downy and Hairy Woodpeckers, Common Crow, Blue Jay, and Brown Creeper. In the southern part of the region, Carolina Chickadees, Tufted Titmice, Red-bellied Woodpeckers, and Carolina Wrens can be an important part of the winter avifauna.

TIMBER MANAGEMENT

Although timber management practices in oak forests vary with geography, site, and species composition, some common strategies apply (Sander 1977, Trimble 1973, Watt *et al.* 1973). Even-aged management through clearcut harvesting is the usual practice. However, because planting oaks is rarely practical, a shelterwood is often used if advance regeneration or anticipated sprout growth is insufficient. Uneven management by group selection can regenerate oaks but is less economical and is difficult to administer and manage.

Species composition and desired products of oak forests vary with site quality. The best sites (site index > 75) are usually managed for saw logs or veneer logs, and fair sites (site index 55-75) are managed for saw logs or pulpwood. If poor sites (site index < 55) have commercial potential, they are managed for pulp. Because the mix of species in oak stands depends on ecological conditions, and regenerated stands come from sprout growth and advance regeneration, species composition goals usually closely follow the natural tendencies. The associated species on the better sites in the northern part of the oak range include sugar maple, white ash, basswood, and black cherry. In the south-central States, yellow-poplar and black walnut can be important, and hickories are common in the southwest part of the oak region. On average sites in the north, white and red pine are found with the hardwoods, and farther south hickories and shortleaf pine are characteristic. On poor sites, jack pine and aspen are common in the north-central States. These marginal stands are managed for pulpwood, wildlife, or converted to conifers such as jack pine or shortleaf pine. If conversion is not prescribed, management is usually minimal. Fair sites are ideal for oaks and are managed for oaks or an oak-hardwood mixture. The lower part of this range of sites is often managed for oak-pine. In stands of intermediate quality, commercial thinning becomes possible. If there is to be only one thinning, it should be done at about 30-40 years because after that time the released trees will not respond well.

On better sites oak forests are managed for oak-hardwoods or converted to pure hardwoods through natural succession of the advance reproduction. This process may be accelerated by spraying oak sprout-growth. Oak-hardwood stands may be thinned to 60 percent of stocking as often as every 10 years up until 3/4 of rotation age. Best results are obtained by thinning intermediate trees from below to release the more vigorous, dominant trees.

Rotation age varies with site and desired product. Forests managed for sawtimber have rotation ages of 60 to 120 years, and forests managed for pulp have rotation ages of 40-60 years. But rotation age can be shortened by appropriate thinnings.

The stand size of oak forests may vary according to physical, economical, or silvicultural considerations. The lower limit to stand size is fixed by efficiency of harvesting and the need for the intolerant oaks to be released from the influence of nearby mature trees. In addition, animal browse activity can be more severe in small plots. As a result, stands are usually not less than 2-5 acres. The upper limit is about 100 acres and is often determined by topography and the age distribution of the management unit. Concerns about soil erosion, water quality and quantity, and nutrient losses and factors such as wildlife habitat diversity and aesthetics all tend to keep stand size down. Also, very large stands are difficult to work into an acceptable rotation schedule.

MANAGEMENT IMPACTS ON AVIAN COMMUNITIES AND SUGGESTED GUIDELINES

The effects of timber harvesting on avian populations varies during the life of the regenerating stand. Clearcutting and shelterwood regeneration usually cause a drastic reduction in the avian community population size and an almost complete turnover in species composition the first growing season after harvest. However, vigorous sprout growth often results in second-year populations higher than those of mature stands. Peak density and diversity of birds probably occurs 5 or 6 years after cutting on most sites, though peaks might be reached later in understocked stands. When regenerating stands shade out the shrub layer, the density and diversity of birds is reduced. Open, less productive woodlands may be more favorable to a wider range of species at this stage due to greater foliage stratification. Avian communities similar to those of mature forests generally develop when the dominant and codominant trees reach 40 to 50 feet in height. At that point, bark foragers are well-established and ground-feeding birds have reappeared. If the loss of undergrowth in regenerating stands is marked, species such as Wood Thrushes and Rufous-sided Towhees can show a bimodal distribution, with peaks in the mature forest and late clearcuts.

The principal difference between clearcut and shelterwood harvests is in the reduced populations of bird species in the residual trees of the latter. Other species found in shelterwoods, such as Northern Orioles or Blue-gray Gnatcatchers, may be absent from any other stage of oak forest development. If small residual trees are left during harvesting operations, they may provide sufficient habitat diversity to allow some foraging by birds from surrounding forest areas, or to allow earlier invasion by species with a preference for elevated song perches (Alder Flycatcher, Golden-winged Warbler, etc.). Another habitat factor that can operate under the shelterwood system is a higher probability of associated shrub species gaining temporary dominance over oak sprouts and seedlings during the younger years of the stand. This tends to favor ground-feeders over the smaller finches and warblers.

Thinning Practices

Thinnings open the canopy and make it less useful for insectivores but create better opportunities for flycatchers and other pursuers. As thinned stands mature, the dominants may develop fuller crowns, which are favorable to several bird species that are scarce or uncommon in oak forests. If the thinning substantially releases the undergrowth, bird species using those layers will be enhanced. Conversely, those species will be eliminated if the underbrush is removed to stimulate tree growth or as part of a "whole tree" chipping operation. This results in a larger proportional decrease in avian biomass in oak forests than in other forest types where species of the upper strata are usually more dominant (table 1). In addition, understory removal may not even be justified by its contribution to tree growth (Dale 1975).

Rotation Age

The major impact of adjusting rotation age will be on the bark foragers, and primary and secondary cavity nesters. Rotation age should be long enough to allow a sufficient number of trees to die for the cavity excavators to utilize and to optimize the foraging substrates for birds that search for prey on tree bark surfaces. In addition, dead trees of all sizes are used as song perches by many birds, and some species also favor snags as perches from which to hawk or sally after prey. When forests are harvested, enough snags should be saved to accommodate the projected number of cavity nesters at the different stages of regeneration, while allowing for the expected attrition of snags during the rotation period. The species, size, and condition of trees preferred by each species of woodpecker needs further research (Conner 1978).

Another benefit to nongame birds from long rotations is the increased populations of birds--chiefly warblers--that select forests with more stratified foliage. Consequently, some portion of the stands in a management unit should be left as old growth. In stands of shorter rotation, it may be necessary to create artificial snags (Conner 1978).

Single Species Management

Bird species requiring young growth are accommodated by normal timber harvesting. This leaves a small number of species with more specialized or unusual requirements that may require specific management prescriptions. However, the land manager can do little to enhance species that are rare in an area because their distributions are centered in another forest type or geographical region, nor can he manage for species that have population size depressed by factors that are not habitat related. The problem of maximizing the populations of the more common species is a second-order concern, and is complicated not only by our lack of specific knowledge of each species but also by the virtual certainty that such prescriptions would contradict or conflict with one another. Although optimization of a group of individual species populations among all stands is easily handled by modern methods, it will always be difficult to assign relative values to the more common bird species.

Stand Size

A very general account of species number and area relations was given above. When avian census results are broken down into subplots, the species count is usually complete after about 5 ha (fig. 2). However, this includes some partial territories in census plots that are a portion of a larger, forested area. While most of the smaller songbirds have home ranges of less than 5 acres, very few species use all of the suitable habitat available to them. Most bird species show very patchy distributions so rare species usually result more from fragmentation than dilution. The density of a particular avian population is rarely related simply to the census area divided by the average home range size.

The ideal stand size is probably about 10 to 20 acres and would accommodate several individuals of the both common and uncommon species. Stands that are too large tend to decrease overall habitat diversification. Birds with large home ranges can almost always use several proximate large patches of habitat, or a variety of habitat types.

Tree Species Composition

Tree species composition of eastern deciduous forests has little effect on bird communities because most birds select habitats by vegetation structure rather than by the tree species or genera that compose the forest. Any avifaunal differences between oak stands and mixed hardwood stands with greater plant variety are almost certainly due to differences in productivity and/or vegetation structure. However, forests containing appreciable densities of trees bearing usable seeds could receive more winter use by birds in some years, but there is no conclusive data to support this idea. Another question that needs further research is the possibility that trees with smooth bark surfaces such as aspen may contain fewer arthropods than those with rough bark. If so, bark foragers could be less prevalent in forests stocked with smooth-textured tree surfaces.

The management practice with the most potential to severely affect bird communities is conversion of hardwood stands to conifer plantations. Oak stands on poorer sites are often converted to red, jack, or shortleaf pine. Although such plantations may have higher winter bird densities, they would support a much lower density and diversity of breeding birds due to their extreme structural simplicity and scarcity of dead trees. In addition, undergrowth may be virtually eliminated for most stages of the rotation by site preparation, release, and shading.

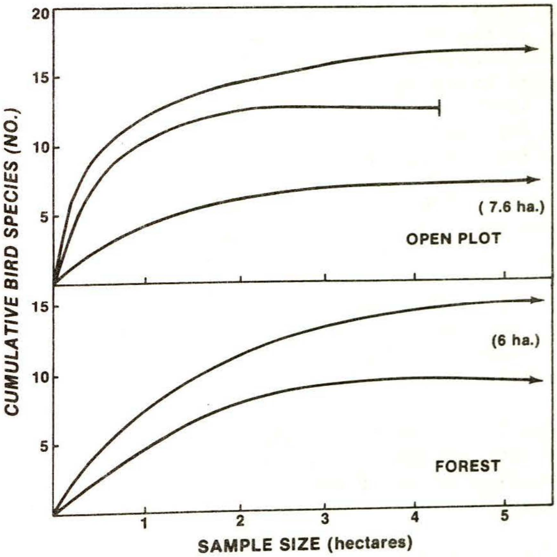

Figure 2.--*Species-area curves for open and forest study areas, which plot cumulative bird species vs. size of plot subset for selected plots of contrasting diversity. All plots show a plateau before 4 ha size. The minimum plot size was 4 ha and most were 6 ha or more. This would indicate that sampling sufficiency for species number has been achieved. The three truncated curves (indicated by arrows) show no increase in cumulative species through their full areas of 6 ha for the forest and 7.6 ha for the open plot.*

In summary, the density and diversity of breeding birds in oak forests can be enhanced by practices that increase the rotation age, structural complexity, and the variety of stands. Some mixture of conifers in some forests benefits both the breeding and winter avifauna, but conversion to pine plantations is detrimental to many breeding populations.

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Wednesday, January 24

NONGAME BIRD HABITAT MANAGEMENT

Moderator: Ruth L. Hine
Wisconsin Department of
Natural Resources

MANAGEMENT OF NORTHEASTERN PINE FORESTS FOR NONGAME BIRDS

David E. Capen[1]

Abstract.--Forests of white, red, jack, and pitch pine may be managed to provide productive habitat for nongame birds. Diverse avian communities often inhabit stands of pine, but few species are restricted to pine forests. Single-species and multi-species wildlife management philosophies are discussed and are related to four principles of managing forest habitat for nongame birds. Even-aged silviculture is recognized as the predominant harvesting practice in pine forests. Forest management which promotes natural regeneration, hardwood understories, and old-growth stands is recommended to enhance habitat for birds. The endangered Kirtland's warbler nests only in young stands of jack pine and is a reminder that pine forests should not be overlooked as wildlife habitat.

INTRODUCTION

Wildlife managers often regard pine forests as "biological deserts" (Castles 1974). Indeed, an intensively managed pine forest may represent a structurally "sterile" habitat for birds (Wiens 1978), and there is a resulting tendency to ignore nongame bird populations in pine forests. Shugart et al. (1978) cautioned that a disregard for bird communities of pine forests could create future shortages in critical habitat for some species. The endangered status of the Kirtland's warbler, which occurs only in stands of jack pine, serves to remind us of this point. Intensive timber management may effectively create biological deserts where extensive stands of pine forests occur; alternatively pine stands may be managed to provide productive habitats for birds.

The objectives of this paper were (1) to review the silvics and management of pine forest types which occur in the northeastern and north central states; (2) to describe the bird communities associated with pine forest types; and (3) to propose management considerations and practices which will allow pine forests to be managed as productive habitat for nongame birds. I have suggested management alternatives which favor nongame birds, and have ignored, within reason, other demands upon the resources of forests. It will be the function of this paper, then, to provide recommendations which will allow optimum benefits for nongame birds in pine forest habitats. Hereafter, wildlife biologists involved in natural resource decision-making processes may be better prepared to propose management compromises which will benefit the nongame resource.

Scientific names of all animals and plants mentioned in this paper are presented in Appendix I.

SILVICS AND SILVICULTURE OF PINE FORESTS

Jack Pine

Jack pine grows farther north than any other American pine (fig.1). It occurs in regions where rainfall is rather low and the frost-free period ranges from 80 to 120 days. The species can sustain itself on quite dry sandy or gravelly soils, but does best on well-drained loamy sands (Fowells 1965). Jack pine is most often found on areas which have been burned. This species is a major component of four forest cover types. It is dominant in the jack pine type, and shares dominance with

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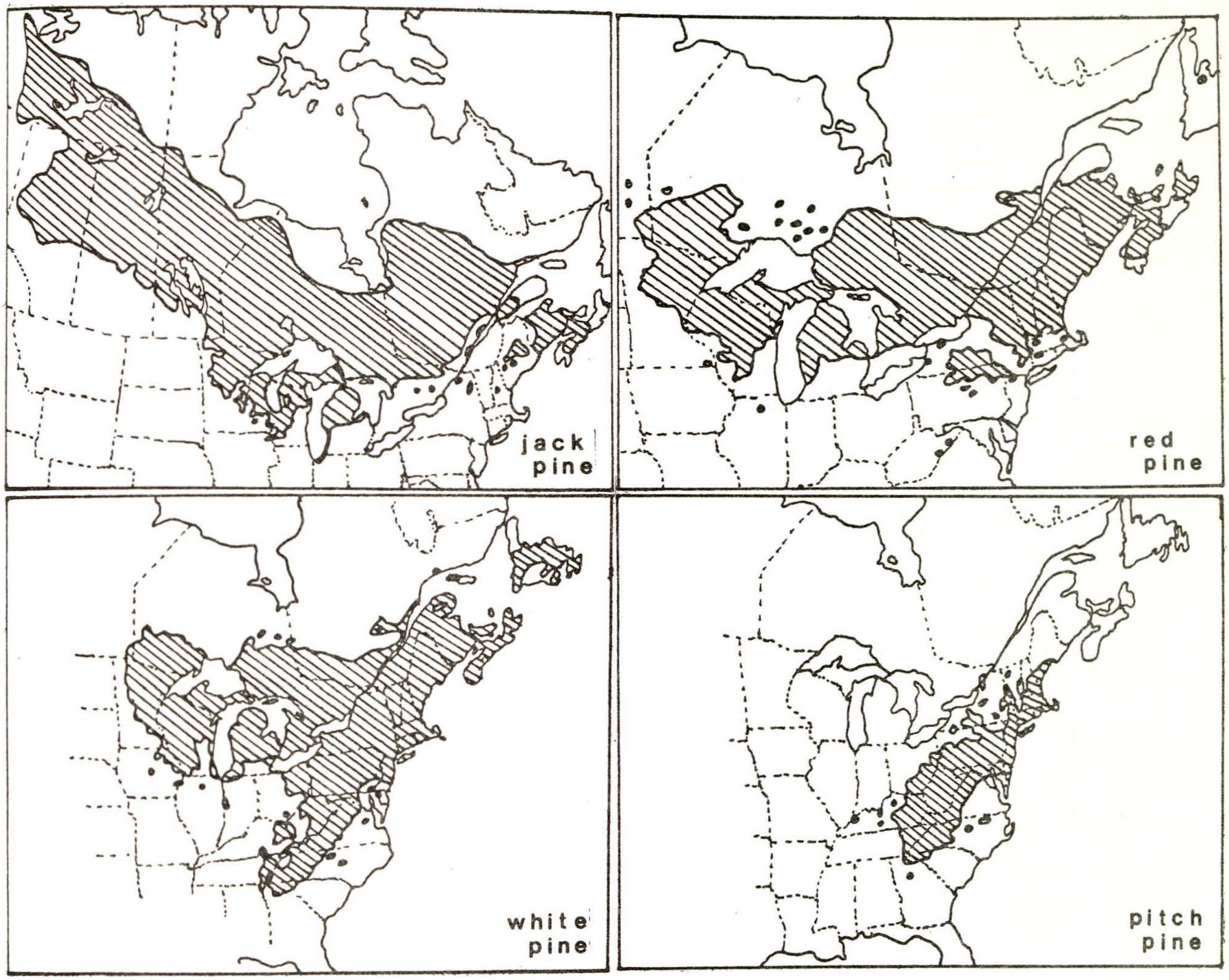

Figure 1.--Ranges of pine forests in north central and northeastern United States and Canada (Little 1971).

paper birch, black spruce, and aspen in other types.

Jack pine characteristically has serotinous cones, which usually do not open until exposed to fire or ground surface temperatures. Nonserotinous cones are common in limited portions of the range (Benzie 1973a). Regeneration is by seeding and usually follows fire. Both germination and seedling survival is best on mineral soil where there is some shade (Fowells 1965).

Jack pine is quite intolerant of shade, and usually functions as a pioneer species. It is one of the fastest-growing conifers in its range for the first 20 years. In the absence of fire, jack pine is usually replaced by more tolerant species, but may form an edaphic climax on the poorest, driest sites (Fowells 1965).

Jack pine currently occupies about 1 million hectares of forest land in the Lake States, but this acreage is decreasing as jack pine stands are converted to other species (Benzie 1977a). Overall management objectives are twofold (Benzie 1977a): (1) to maintain the jack pine type where it is the best suited species, i.e. on dry, outwash, sandy soils; and (2) to replace it with more productive species on better sites at the end of the jack pine rotation.

Clearcutting is the recommended silvicultural system for harvesting mature trees (Benzie 1973a, 1977a). The serotinous cones on slash from clear-cuts will open and seed naturally with normal ground-surface temperatures. Intensive site preparation, which usually involves prescribed burning, and planting or broadcast seeding is also used. The seed tree system is an alternative practice, but prescribed burning is necessary to prepare the seedbed and open serotinous cones. A shelterwood system is recommended as another alternative, but is most practical in well-stocked stands where cones are nonserotinous (Benzie 1973a).

Jack pine is a short-lived species, hence rotation ages are less than recommended for other pines. Stands are often cut for pulpwood at 40 to 50 years of age with no intermediate commercial thinnings. Thinnings may be prescribed on better sites where merchantable poles and sawtimber may be grown on 70-year rotations. Numerous diseases and insects affect jack pine and prompt managers to restrict rotation ages as much as possible.

Red Pine

The present range of red pine corresponds closely with areas affected by late Pleistocene glaciation (fig. 1). Its distribution corresponds with a zone of low to moderate rainfall, and frost-free periods which range from 80 to 160 days. Red pine grows on better soils than jack pine, and is found chiefly where soils are acidic and have good drainage and aeration. The species is a component of three forest cover types: red pine, jack pine, and white pine. Most species associated with red pine, except white pine, are usually found in the understory (Fowells 1965).

Reproduction is by seed and regeneration is most successful on mineral soil. Seedlings will not grow beneath heavy litter, sod, dense slash, or heavy ashes. Many old-growth stands have been established after fire when a good seed year corresponded with a light cover of ashes. Red pine seedlings grow slowly, and shaded seedlings may require 15 years to reach breast height. Growth rate is more rapid from the sapling stage to maturity, however, and basal area growth may still be constant at 200 years of age (Fowells 1965).

Red pine is less tolerant of shade than most of its associates, but more so than jack pine (Fowells 1965). A forest sere in the Lake States may be from jack pine to red pine to white pine, and finally to northern hardwoods. On infertile, sandy sites, succession may stop short of hardwoods, and red pine may be a persistant subclimax (Benzie 1973b). In the eastern portion of its range, red pine may be a successional stage in a spruce-fir or hemlock climax, rather than a climax of northern hardwoods.

A century ago, red pine covered about 2.8 million hectares of forest land in the Lake States. Today it covers only a little more than 400,000 hectares, mostly planted since 1930 (Benzie 1977b), and is the most intensively managed coniferous type in the region. The usual management objective is to grow red pine in essentially pure, even-aged stands. Benzie (1973b) stated that clearcutting is the most commonly used silvicultural practice, and considered seed tree systems inefficient. However Heeney (1978) recommended against clearcutting, in favor of seed tree or shelterwood systems. A strip-shelterwood practice is often employed where narrow strips of mature trees are left in an initial cut which completely clears wider strips. A later cut, after regeneration of the clearcuts, removes the mature trees and leaves the narrow strips to be used as access for later operations (Benzie 1973b, Heeney 1978).

The most favored management for red pine involves all the forestry operations which are commonly associated with pine monocultures (Benzie 1977b). Site preparation often involves mechanical treatment, herbicidal applications, and/or prescribed burning. Broadcast seeding is encouraged, but the most reliable method of establishing a red pine stand is to plant nursery-grown trees. Treatments to release seedlings usually involve herbicides. Mechanical cleaning is often needed when the trees are in the sapling stage. Thinning is advisable in the pole and sawtimber stages and stands that are thinned regularly need artificial pruning to produce good saw logs. Prescribed burning is recommended to reduce undergrowth before harvesting a mature stand. Rotations of 60 to 100 years are most commonly recommended, but the maintenance of some old growth stands to 200 years of age is suggested.

Eastern White Pine

The range of eastern white pine corresponds with a cool, humid climate and a growing season of 100 to 200 days (fig. 1). White pine grows on practically all soils within its range, but is most closely associated with well-drained sandy soils. The species is a major component of four forest types, one of which is the white pine type, and is an associate in 14 other types (Fowells 1965).

Regeneration is exclusively by seeding, and good seed crops occur at intervals of 3 to 5 years (Fowells 1965). A seedbed of moist, mineral soil is necessary for germination. Scarification and prescribed burning are often used to create favorable seedbeds (Little et al. 1973). Early growth of white pine is slow, but becomes more rapid between 10 and 20 years. It is a long-lived species and almost never becomes stagnant in pure stands (Fowells 1965).

Ecologically, white pine is a versatile species and may function as a pioneer, a long-lived intermediate, or a component of the climax forest. It is considered to be intermediate in tolerance to shade, but is quite susceptible to shade when in the slow-growing seedling stage (Fowells 1965).

Little et al. (1973) list clearcutting, strip cutting, seed tree cutting, shelterwood cutting, and group selection as the silvicultural methods used in regenerating white pine. Some foresters believe that white pine cannot succeed itself, and indeed, this is partially true without proper forest management practices. A two-cut shelterwood system is the preferred practice (Lancaster and Leak 1978). The first cut removes 40 to 60 percent of the overstory and is made during or immediately after a good seed year. The second cut to remove the shelter trees comes 5 to 10 years later when the seedlings have begun a rapid growth. It is often recommended that hardwood regeneration be treated with a herbicide before the first cut and sometimes repeated before the second cut (Lancaster and Leak 1978).

Many of the stand prescriptions in Lancaster and Leak's (1978) silvicultural guide suggest management of white pine in harmony with hardwoods where site conditions are good. Group selection is often the recommended silvicultural practice in these stands.

Pitch Pine

Pitch pine grows in humid climates along the Atlantic coast (fig. 1). Its distribution is spotty because it is usually found on poor, shallow soils of sandy or gravelly texture. It does, however grow in a wide range of moisture conditions. The species is a minor component in 12 forest cover types, but is only dominant in one type. It is often found in association with one of several species of scrub oaks (Fowells 1965).

The most extensive stands of pitch pine are found in southern New Jersey (Fowells 1965). Here, the "pine barrens" occupy over 470,000 ha of wildlands which are only minutes away from Philadelphia and New York City (McCormick 1970). The region is almost entirely free from industrial and agricultural development. Pitch pine forests are of little, if any, commercial importance for timber.

The ability of pitch pine to regenerate vegetatively is outstanding. Dormant buds, often protected in seedlings by a basal crook, sprout prolifically after fire or other damage to the stem. The form and growth rates of sprouts decrease with increased age of the root crown beyond 20 years. Wildfires at frequent intervals, then, can result in a stand of slow-growing sprouts from old root systems. Pitch pine may live for 200 years, but growth starts to decline as early as 20 years of age (Fowells 1965). It is a species which is intolerant of shade, and requires mineral soil for germination. Fire has largely maintained the pitch pine type, and has been responsible for the sprout origin and poor form that characterize the species (Little and Moore 1949, Fowells 1965).

AVIAN COMMUNITIES

I have restricted the discussion of avian communities of northeastern pine forests to the breeding season. This limitation is necessary because published information pertains largely to breeding birds, and is somewhat justified because the number of terrestrial bird species may be reduced by as much as 50 percent in the winter months (calculated from Gauthreaux 1978). It should be recognized, however, that pine forests may be more important habitats for birds in the winter, than during the nesting season, because of an energetic advantage provided by dense foliage (Kelty and Lustick 1977).

Data from published breeding bird censuses (*Audubon Field-Notes* and *American Birds*) were summarized for this discussion of the composition of avian communities and trends in avian succession which correspond to the forest sere. I divided this section into communities characteristic of white, red, and jack pine forests and those of pitch pine forests. This division was rationalized because of structural, silvical, and silvicultural similarities among white, red, and jack pine forests and corresponding differences in pitch pine environments. It is widely accepted that breeding birds select habitats on the basis of vegetative structure rather than plant species composition (Hilden 1965, Balda 1975, and others).

White-Red-Jack Pine

Species Composition and Richness

The Kirtland's warbler, an endangered species, and the pine warbler, which is never abundant, are the only two species which occur in the northeastern states and are found exclusively in pine forests. Numerous species occuring predictably in pine forests, but also present in other coniferous types, deciduous types, or mixed pine and hardwood forests are the black-capped chickadee, red-breasted nuthatch, golden-crowned kinglet, ruby-crowned kinglet, yellow-rumped warbler, and chipping sparrow. Pine forests may support a rich community of breeding birds (table 1).

Table 1.--Occurrence and density of 48 species of breeding birds in seral stages of white, red, and jack pine forests. Density is expressed as number of territorial males per 10 ha: xxxx = ≥ 10; 5 ≤ xxx < 10; 1 ≤ xx < 5; x < 1. Frequency indicates the number of times each species occurred in published breeding bird censuses (*Aud. Field-Notes* and *Am. Birds*).

	Seral stages				
Breeding birds	Seedling, sapling[1/]	Pole	Mature	Mixed pine/hardw.	Total freq.
Common flicker	–	–	–	xx 1	1
Pileated woodpecker	–	–	–	x 1	1
Yellow-bellied sapsucker	–	–	xx 1	xx 1	2
Hairy woodpecker	–	–	–	x 1	1
Downy woodpecker	–	–	–	x 1	1
Great-crested flycatcher	xx 1	–	xx 1	–	2
Eastern wood pewee	xx 1	–	xx 1	xx 2	4
Olive-sided flycatcher	–	–	–	x 2	2
Blue jay	x 1	xx 3	x 3	–	7
Black-capped chickadee	xx 1	xx 3	xx 2	x 2	8
White-breasted nuthatch	–	–	x 1	x 1	2
Red-breasted nuthatch	–	–	xx 2	–	2
Brown thrasher	xx 4	–	–	–	4
American robin	xx 3	xxxx 1	xx 3	xx 2	9
Hermit thrush	–	xx 2	x 2	xx 2	6
Wood thrush	–	–	xx 2	–	2
Veery	–	–	xx 3	xxx 1	4
Golden-crowned kinglet	–	–	xx 1	–	1
Ruby-crowned kinglet	–	–	x 1	–	1
Cedar waxwing	xx 3	xx 1	–	xx 1	5
Solitary vireo	–	–	x 2	x 1	3
Red-eyed vireo	x 1	–	xx 2	xx 2	5
Black & white warbler	–	xx 1	xx 2	x 2	5
Nashville warbler	xx 1	xx 2	–	–	3
Yellow warbler	x 1	xxxx 1	–	–	2
Magnolia warbler	xx 1	–	–	xx 1	2
Yellow-rumped warbler	xx 1	xx 2	xx 2	xx 1	6
Black-throated green warbler	–	–	xxx 2	xx 2	4
Blackburnian warbler	–	–	xxx 3	x 2	5
Chestnut-sided warbler	–	–	–	x 2	2
Pine warbler	–	–	xxx 1	–	1
Kirtland's warbler	x 1	–	–	–	1
Ovenbird	–	xx 3	xxx 4	x 2	9
Mourning warbler	–	xx 1	–	xx 1	2
Common yellowthroat	xx 2	xxx 1	–	xx 2	5
Canada warbler	–	–	xx 1	xx 1	2
American redstart	–	–	–	x 2	2
Scarlet tanager	–	–	xx 2	x 1	3
Rose-breasted grosbeak	x 1	–	x 1	x 1	3
Purple finch	xx 2	–	xx 1	x 1	4
American goldfinch	xxx 1	xxx 1	xx 1	x 2	5
Rufous-sided towhee	xx 2	xxx 3	xx 2	x 1	8
Vesper sparrow	xx 3	–	–	–	3
Dark-eyed junco	xxx 1	–	xx 3	x 1	5
Chipping sparrow	xxx 4	xxxx 1	xx 3	xx 1	9
Field sparrow	xxx 3	xx 1	–	–	4
White-throated sparrow	x 1	–	x 2	xxx 2	5
Song sparrow	xxxx 2	xx 1	–	xxx 1	4
Number of censuses	4	4	4	2	14

[1/] One of the young sapling study plots contained some scattered dead hardwoods, which resulted in the occurrence of species such as great-crested flycatcher and black-capped chickadee.

Table 2.--Richness and density of breeding birds in seral stages of white, red, and jack pine forests. Refer to Appendix II for additional habitat and census data.

Forest stand description	Size of study plot (ha)	No. species	No. territories		Location, Reference
			Study plot	Km^2	
Jack pine regeneration	6.5	12	12.5	193	Michigan, Munn 1974
Young red pine plantation	4.8	6	15	312	Ontario, MacDonald 1965
Young mixed pine plantation	8	31	62.5	813	Ontario, Oelke 1967a
Pole-stage white pine plantation	7.5	7	11.5	153	Massachusetts, Lloyd-Evans 1975b
Pole-stage red pine plantation	4.8	1	1	21	Ontario, MacDonald 1965
Pole/mature jack pine forest	28	11	25	88	Ontario, Erskine 1971
Mature jack pine forest	12	14	50	417	Minnesota, Niemi 1974
Mature white pine forest	7	27	50.5	694	Ontario, Oelke 1967b

Richness (i.e. number of species) is characteristically lower in coniferous forests than in deciduous or mixed forests (Tramer 1969); and pure pine forests do not provide exception to this rule (Driscoll 1977, Dickson 1978, Meyers and Johnson 1978). Table 2 contains a summary of the findings of eight bird censuses in seral stages of white, red, or jack pine stands. Fewer than 15 species of birds were present on all but two plots, and scattered hardwoods on these two areas may have accounted for the increased richness (appendix II). Twenty or more species are characteristically found in deciduous stands or mixed forests (Tramer 1969, Meyers and Johnson 1978).

Successional Trends

Breeding bird censuses of pine forests were assigned to four habitat classes: seedling and sapling, pole stage, mature forest, and mixed pine and hardwoods. The first three classes are common management delineations, while the mixed forest class represents an advanced seral stage in the succession towards a hardwood climax.

The seedling-sapling stage was dominated by granivorous birds and some common edge species (table 1). Richness was predictably low in two studies (Munn 1974, MacDonald 1965), but unusually high on a tract studied by Oelke (1967a) where patches of hardwoods, including snags, and nest boxes contributed to high numbers of breeding birds (table 2).

Brooks (1970, 1975, 1977, 1978) conducted breeding bird censuses in a scotch pine plantation for 8 consecutive years and provided another example of increased species richness and density when woody vegetation was associated with young pines (table 3). The high densities of birds in Brooks' studies were largely song sparrows and chipping sparrows. The numbers of American robins and purple finches gradually decreased as plant succession progressed during the 8 years of Brooks' censuses. Accordingly, breeding pairs of common yellowthroats increased steadily as woody undergrowth increased (table 3).

The diversity of breeding birds may be at its lowest in dense pole-stage pine stands because closure of the canopy leads to elimination of the understory and ground cover. Pine plantations with trees spaced at regular intervals will feature the most complete canopy closure. The resulting dearth of nesting in closed stands was most dramatically illustrated by MacDonald (1965) who found only one territorial male, a yellow-rumped warbler, on a 4.8 ha plot in a red pine plantation. Naturally-stocked stands of pole-stage pines may have closed canopies as well, but patchy openings in the canopy are more likely and will allow development of the understory.

Species richness and density were found to increase in mature stands of pine and mixed pine and hardwood forests (tables 1,2). This observation was consistent with general trends of increasing diversity and density associated with forest succession (Shugart and James 1973, Kricher 1973). Oelke (1967b) reported a particularly rich census of breeding birds, 27 species, Table 3.--Breeding birds of an upland scotch pine plantation, Allegany Co., New York from 1970 - 1977 (Brooks 1970 - 1975, 1977, 1978).

Description of habitat: Meadow planted to scotch pine in 1958; trees trimmed annually since 1962 to 2 m high and harvested regularly since 1970; grass and forb cover between trees; choke cherry and brambles increased from 1973 - 1977. Plot was 9.3 ha with diverse edges.

		No. territories		No. territories				
Year	Species	9.3 ha	km^2	Song sparrow	Chipping sparrow	American robin	Purple finch	Common yellowthroat
1970	12	106	1144	31	26	21.5	10	1
1971	18	84	902	23	14.5	13	8	+
1972	17	108	1155	31	23	13	9	+
1973	15	89	956	23	17	11	8	2
1974	18	94	1005	28	17	10	8	4
1975	14	80	854	23	19	7.5	4	6
1976	23	105	1128	28	21	5	5	8
1977	23	86	924	25	20	4	4	9
Mean	17.5	93.8	1008.5	26.5	19.7	10.6	7	3.9
Range	12-23	84-107	854-1155	23-31	14.5-26	4-21.5	4-10	+-9
C.V.				13	19	52	33	88

Other abundant species (mean no. territories): Field sparrow (7.9), Rufous-sided towhee (3.6), American woodcock (2.7), Yellow-rumped warbler (2.6).

in a white pine forest with an open canopy and a diverse hardwood understory.

Pitch Pine

Species Composition and Richness

The checklist of birds for the pine barrens of New Jersey lists the occurrence of 144 species (McCormick 1970), but many of these are water birds, rare species, and records of migratory birds which do not nest in pitch pine forests. The breeding avifauna of pitch pine forests is characterized by few species represented by numerous individuals (table 4).

Many of the birds found nesting in pitch pine forests select the characteristic understory of scrub oaks and the blueberry and huckleberry ground cover rather than the pine overstory. The rufous-sided towhee most typifies pitch pine forests, but is a shrub and ground-dwelling species. Other species which prefer understory vegetation and predictably breed in pitch pine stands are common yellowthroats, prairie warblers, and brown thrashers. Frequent fires produce abundant cavity-nesting sites for several species of woodpeckers, black-capped chickadees, and eastern bluebirds. The open habitat of pitch pine forests is preferred by bluebirds. In addition to the abundant towhee, ground-nesting species most common in pitch pine include whip-poor-wills, common nighthawks, and ovenbirds. Only pine warblers, eastern wood pewees, and blue jays are found consistently in the canopy.

Successional Trends

Because pitch pine forests are not extensively harvested and frequent fires prevent old growth, succession is typically accelerated in the early stages and truncated before maturity. Thus the avian community is characteristic of mid-successional vegetative structure. Lloyd-Evans (1973, 1975a, 1977) conducted censuses which allowed comparisons of richness and abundance of breeding birds in pitch pine stands at different intervals following fire (table 5). His studies indicate that understory plants and breeding birds of the low vegetative strata responded vigorously only one year after a burn.

Fables (1947, 1948, 1954) censused breeding birds in the New Jersey pine barrens for 17 consecutive years (table 6). His studies began 8 years after a fire and continued until the study plot had been free from fire for 24 years. This long-term study showed remarkable stability in the richness and density of the avifauna of a mid-successional pitch pine forest.

SILVICULTURAL MANAGEMENT OF HABITAT

An historical and comprehensive review of man's silvicultural influence on wildlife habitat was presented by Perkins (1974). A subsequent review by Schemnitz (1976) emphasized the

Table 4.--Occurrence and density of 29 species of breeding birds in successional stages of pitch pine forests following fire. Density is expressed as number of territorial males per 10 ha: xxxx = ≥ 10; 5 ≤ xxx < 10; 1 ≤ xx < 5; x < 1. Frequency indicates the number of times each species occurred in published breeding bird censuses (*Aud. Field-Notes* and *Am. Birds*).

Breeding birds	No. years following fire				Total freq.
	0-1	2-10	11-20	21+	
Mourning dove	–	x 3	x 2	x 2	7
Black-billed cuckoo	–	x 1	x 1	–	2
Yellow-billed cuckoo	–	x 1	x 1	x 2	4
Common nighthawk	–	x 2	x 2	x 1	5
Whip-poor-will	x 2	x 3	xx 3	x 2	10
Common flicker	xx 3	x 3	x 2	x 3	11
Hairy woodpecker	xx 1	xx 1	x 1	–	3
Downy woodpecker	x 1	x 2	x 3	x 2	8
Eastern kingbird	x 2	x 2	x 1	x 3	8
Eastern wood pewee	xx 3	x 2	x 3	x 2	10
Blue jay	xx 3	x 1	x 3	x 3	10
Eastern bluebird	xx 3	x 3	x 3	x 2	11
Hermit thrush	xx 3	xx 1	–	xx 1	5
American robin	xx 2	xx 1	x 2	–	5
Gray catbird	–	x 1	x 3	xx 1	5
Brown thrasher	xx 2	xx 3	x 3	x 2	10
Black-capped chickadee	x 1	x 2	–	xx 1	4
Tufted titmouse	–	–	x 1	x 2	3
House wren	xx 1	xx 3	x 3	x 2	9
Black & white warbler	–	x 2	x 2	x 2	6
Pine warbler	–	xx 2	xx 3	x 2	7
Prairie warbler	xxxx 2	xxx 3	x 1	xxxx 2	8
Ovenbird	–	x 1	x 1	x 2	4
Common yellowthroat	xxx 2	xxx 3	xx 3	xxx 3	11
American goldfinch	–	–	x 3	x 1	4
Rufous-sided towhee	xxxx 3	xxx 3	xxx 3	xxxx 3	12
Chipping sparrow	–	x 2	x 3	x 2	7
Field sparrow	xxx 1	xx 3	x 2	xx 1	7
Song sparrow	–	x 2	x 3	x 2	7
Number of censuses	3	3	3	3	12

Table 5.--Richness and density of breeding birds in stands of pitch pine-scrub oak following fire and insect damage (Lloyd-Evans 1973, 1975a, 1977). Refer to Appendix III for additional habitat and census data.

Descriptive variables	Forest stand identification					
	IV-74	IV-75	III	II	V	I
Size of census plot (ha)	7.5	7.5	7.5	7.5	7.5	7.5
Years after fire	0	1	2	10	[1]	30
No. bird species	6	18	13	16	22	12
No. territories	16	33	46	60	38	52
Territories/km^2	207	440	553	807	500	693

[1] 5 years after insect infestation killed pines.

Table 3.--Breeding birds of an upland scotch pine plantation, Allegany Co., New York from 1970 - 1977 (Brooks 1970 - 1975, 1977, 1978).

Description of habitat: Meadow planted to scotch pine in 1958; trees trimmed annually since 1962 to 2 m high and harvested regularly since 1970; grass and forb cover between trees; choke cherry and brambles increased from 1973 - 1977. Plot was 9.3 ha with diverse edges.

		No. territories		No. territories				
Year	Species	9.3 ha	km^2	Song sparrow	Chipping sparrow	American robin	Purple finch	Common yellowthroat
1970	12	106	1144	31	26	21.5	10	1
1971	18	84	902	23	14.5	13	8	+
1972	17	108	1155	31	23	13	9	+
1973	15	89	956	23	17	11	8	2
1974	18	94	1005	28	17	10	8	4
1975	14	80	854	23	19	7.5	4	6
1976	23	105	1128	28	21	5	5	8
1977	23	86	924	25	20	4	4	9
Mean	17.5	93.8	1008.5	26.5	19.7	10.6	7	3.9
Range	12-23	84-107	854-1155	23-31	14.5-26	4-21.5	4-10	+-9
C.V.				13	19	52	33	88

Other abundant species (mean no. territories): Field sparrow (7.9), Rufous-sided towhee (3.6), American woodcock (2.7), Yellow-rumped warbler (2.6).

in a white pine forest with an open canopy and a diverse hardwood understory.

Pitch Pine

Species Composition and Richness

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Gray catbird	-	x 1	x 3	xx 1	5
Brown thrasher	xx 2	xx 3	x 3	x 2	10
Black-capped chickadee	x 1	x 2	-	xx 1	4
Tufted titmouse	-	-	x 1	x 2	3
House wren	xx 1	xx 3	x 3	x 2	9
Black & white warbler	-	x 2	x 2	x 2	6
Pine warbler	-	xx 2	xx 3	x 2	7
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Ovenbird	-	x 1	x 1	x 2	4
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Territories/km^2	207	440	553	807	500	693

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Table 6.--Breeding birds of typical New Jersey pitch pine barrens, 1938-1954 (Fables 1947, 1948, 1954).

Description of habitat: 1930- most of plot was burned; 1938- pine regeneration 2 m high, scrub oak 1.6 m high; 1941- burned and unburned areas similar in appearance; 1945- pine spreading laterally; 1954- nine summer homes erected on plot. Study plot was 31 ha and included a 2 ha cedar bog.

Species	Mean (15 yrs)[1]	Range	No. years after 1930 fire		
			8-12 (1938-42)	13-18 (1943-48)	21-24 (1951-54)
			Mean no. territories		
Rufous-sided towhee	20.7	12-33	16	22	24
Prairie warbler	7.4	3-15	8	9	4
Common yellowthroat	4.9	3-8	5	5	4
Whip-poor-will	2.8	1-7	1	4	2
Pine warbler	2.7	1-8	3	3	1
Brown thrasher	2.5	1-4	3	3	2
Gray catbird	2.5	0-5	2	3	2
House wren	2.3	0-5	3	2	1
Chipping sparrow	2.2	1-4	2	3	2
Field sparrow	1.9	0-4	3	2	1
Total no. species	35.1[2]	30-42	35	35	35
Total territories	87.3	64-104	81	94	88
Territories/km^2	277	208-338	270	275	287

[1] Data from 1949-50 not available.

[2] Many species were associated with diverse habitats adjacent to the study plot.

many investigations where effects of silvicultural practices on single species of wildlife were studied. Current and future research must concentrate on silvicultural management of entire faunal communities to complement management philosophies which are increasingly holistic in scope.

Philosophies of Management

Wildlife management, if not most resource management, has been characterized in the past by a single agency implementing decisions concerning a single resource. The philosophy still prevails on much federal, state, and private land, but was legally altered on National Forests in 1960 with the passage of The Multiple Use and Sustained Yield Act. This act dictated a change in thinking and in practice, but multiple-use, nevertheless, has been implemented more by decree and compromise than by design. The trade-offs necessary for scientific multiple-use management depend upon an improved knowledge of inputs and outputs of a resource system (Ripley and Buffington 1974), and upon a better understanding of public desires (Payne and Thomas 1974).

The philosophy of simultaneous consideration of multiple resources led to the featured species concept of managing wildlife (Holbrook 1974, Zeedyk and Hazel 1974, Gould 1977). This concept represented a hybrid between single-species and multiple-resource management. It was predicated on the management of a single wildlife species, but recognized that maximization of both the wildlife resource and the timber resource must be compromised. The featured-species concept should be regarded as no more than a step in the right direction towards a more comprehensive system of management.

A current management philosophy, one with an ecological rather than an economical foundation, is a multi-species concept based on providing habitat diversity (Siderits 1975, Siderits and Radtke 1977). Natural diversity should be pursued, but maximum diversity *per se* is not a suitable management objective (Webb 1977, Weins 1978). High diversity is often equated with ecosystem stability, but that relationship is questionable and is currently being tested (Goodman 1975).

The ultimate management objective is to base decisions on the balance of entire ecosystems. Ecosystem management is a concept which is being addressed by research ecologists (Wagner 1977) as well as resource managers (Graul et al. 1976). Wagner (1977) stated that ecosystem management will ultimately depend upon an understanding of energy flow and community structure.

Principles of Managing Avian Communities

Lack (1933) was one of the first to study habitat selection by birds, and since his early studies much research has addressed resource division among avian species. Many of these studies have been conducted in the past decade or two and complement each other so well that I have identified the following "principles" of managing habitat for avian communities.

1. *Habitat structure is more important in resource partitioning than other dimensions of the ecological niche.* The ecological niche, as defined by Hutchinson (1958), consists of many dimensions, one of which may be comprised of the structural components of the habitat. This dimension is often referred to as the *habitat niche* (Smith 1977). Schoener (1974) reviewed resource partitioning and concluded that for birds habitat dimensions were more important than food-type dimensions or temporal dimensions. He also stated that as the number of species increased, the number of niche dimensions must increase as well. This consideration leads to the conclusion that the diversity of bird species will be strongly dependent upon habitat diversity. Furthermore, diverse habitat for birds may be largely equated with diverse vegetative structure (see Balda 1975 for review).

A classic study by MacArthur and MacArthur (1961) documented a strong relationship between the diversity of breeding birds in a forest and layers of foliage. The results of MacArthurs' study became so widely accepted that biologists (e.g. Meslow 1978) commonly equated vegetative structure with foliage height diversity. Vegetative structure may be defined by many variables, however, and foliage height is only one component of the habitat niche. The recent uses of multivariate statistical analyses in studies of habitat structure have identified numerous habitat variables that may be important in the management of avian habitat (James 1971, Anderson and Shugart 1974, Shugart et al. 1975, Conner and Adkisson 1976).

2. *Plant succession determines avian species composition, diversity, and biomass.* The fact that certain species of birds are characteristic of different stages of the forest sere is well accepted and has been documented in many forest types (Adams 1908, Johnston and Odum 1956, Kendeigh 1948, Martin 1960, Karr 1968). Seed-eating sparrows are predictably found in bare fields and grassland just as bark-probing woodpeckers are associated with mature forests.

Theoretical properties of succession were presented by Margalef (1968) and Odum (1969). Among other attributes, it is believed that successional trends lead to increased species diversity and biomass. Species diversity is most commonly defined by a formula (Shannon and Weaver 1963) which is comprised of two components: *richness* (number of species) and *equitability* (evenness of abundance among species). Odum (1969) predicted that both components increased with succession. Species richness in breeding birds is highly correlated with diversity (Tramer 1969), and richness is commonly accepted as an index of diversity.

Breeding bird diversity roughly corresponds to expected successional trends (Johnston and Odum 1956, Shugart and James 1973, Karr 1968). However, Shugart et al. (1975) cautioned that studies of avian succession have illustrated considerable variability in diversity, and stated that a typical trend has not yet emerged. Variability is also evident when examining trends in density and biomass through succession, but the general pattern in birds is for higher values of both variables as the forest matures (Shugart et al. 1975).

3. *Avian diversity is dependent upon* (a) *vertical habitat diversity,* (b) *horizontal habitat diversity,* (c) *patchiness of habitats,* and (d) *size of forest habitats.* Whittaker (1965) distinguished between within-habitat or "alpha" diversity and between-habitat or "beta" diversity. In the context of habitat management, those distinctions can be viewed as vertical foliage layering within a stand (alpha-diversity), and the juxtaposition of stands of different successional stages and species composition (beta-diversity). Overall avifaunal diversity can be enhanced by increasing opportunities for the vertical distribution of birds within a stand (Dickson and Noble 1978), and/or by providing structural diversity among stands (Edgerton and Thomas 1978, Wiens 1978). This is to say that total avifaunal diversity is greater in the entire forest sere than in any particular seral stage.

Spatial heterogeneity also determines avian diversity. This concept is referred to as habitat patchiness and is least likely to be achieved under intensive even-aged forest management. MacArthur et al. (1962) and Roth (1976) found high correlations between bird species diversity and indices of spatial variability.

The size of forest habitats and the fragmentation of forests should be important concerns in formulating management plans which consider habitat for nongame birds (Forman et al. 1976). Galli et al. (1976) found increased species richness as the size of forest islands increased. "Habitat islands" have also been studied by Whitcomb (1977) and MacClintock et al. (1977). Their research suggested that certain bird species of the forest interior will occur only in large blocks of habitat, although the size of these blocks may be reduced if "habitat corridors" prevent isolation. The importance of habitat islands and corridors is evident, but implications for management are poorly understood at the present time.

4. *Habitat management for nongame birds should consider species assemblages.* It is unlikely that extensive nongame bird management will be conducted on a single-species basis; and I cautioned earlier against managing solely for maximum diversity. Rather, habitat management should be oriented towards carefully-defined groups of species. Several approaches have been suggested to identify suitable species assemblages. *Guilds* contain functionally related species that show similarities in foraging, nesting, and food habits. Theoretically, birds in different guilds do not compete for resources. Assigning birds to guilds may be helpful in identifying management assemblages, but tolerances of individual species to specific niche dimensions should not be overlooked.

Thomas et al. (1976) assigned species to 16 different *life forms*. It was predicted that most species of any life form would respond similarly to a specified management practice. Webb et al. (1977) used experimentation to determine that certain groups of birds responded in predictable ways to habitat alteration. Webb (1977) identified *response groups*, such as the blackburnian warbler group that responded adversely to even a partial removal of the forest canopy. Such response groups might be identified by multivariate statistical techniques such as cluster analysis, utilized by Evans (1978).

General Effects of Even-Aged Management

Even-aged forest management is, and will probably continue to be, the overriding silvicultural practice in forests of white, red, and jack pine. Previous authors (Edgerton and Thomas 1978, Meslow 1978) have predicted the following general effects of even-aged management on bird habitat.

(1) *Early stages of succession are accelerated* through practices of intensive site preparation, seeding, and planting. These practices lead to the rapid replacement of early successional bird species by those that select shrub and sapling habitat.

(2) *Old growth habitats are commonly eliminated.* Long rotations are uncommon in managed pine forests hence the diverse avian communities of mature stands are not encouraged.

(3) *Snags and cavities are often eliminated* by thinning or are not allowed to develop because of short rotations. This effect is more characteristic of intensive clearcutting than of other even-aged practices.

(4) *Monocultures are encouraged.* Monocultures usually lack diverse vegetative structure. They are susceptible to damage from diseases and insects which may lead to preventative measures such as chemical treatments and shortened rotations. For birds, the cures may be worse than the diseases.

Silvicultural Recommendations

Regeneration Cutting

Commercially important northern pine forests managed in even-aged stands are harvested by clearcutting, shelterwood, or seed tree cutting. Clearcutting has the most obvious impact on the vertical structure of habitat and will result in a conversion of the avian community. Such conversions will *generally* reduce species richness and biomass. This may not be the case in pine stands, however, because they are often harvested when commercially mature, rather than ecologically mature, hence richness and biomass may already have been at a minimum.

Clearcutting followed by intensive site preparation effectively reduces the habitat niche to only two dimensions and strongly impacts bird populations. The effects are usually of short duration, however, because herbaceous cover develops rapidly on the burned areas. Clearcutting with *natural regeneration* is a preferred alternative.

The other even-aged management alternatives shelterwood and seed tree harvesting are much less disruptive to the avian community. Although much of the habitat structure is removed by both methods of harvest, opportunities for several functional groups of birds are preserved through the seed-producing trees which are left.

If clearcutting is the selected management option, the size, shape, and location of clearcuts can be planned to enhance avian communities Wildlife biologists have long maintained that clearcut areas should be intermixed as much as possible to produce a habitat with maximum horizontal diversity. However, we have never agreed on an optimum size for these clearcuts. The smaller the cuts, and the greater the admixture of age-classes, the more edge is provided; and wildlifers traditionally have been taught to manage for the edge.

Edge habitat might not be in short supply in a harvesting scheme involving clearcuts of different ages; but areas in the forest interior might be, and there are "forest-interior species" just like there are edge species. How large should stands be to provide for the species of forest interiors? Research on this subject is needed (see Robbins, this Proceedings). This may be merely an academic question in intensively managed pine forests, because forest interior species are usually associated with old-growth habitat. Hence, managers must first lengthen the rotation period to produce mature stands, then be concerned for species of the forest interior.

Intermediate Treatments

Intensive pine silviculture and habitat enhancement for birds are often in conflict as stands develop. The removal of hardwood regeneration by chemical or mechanical means drastically reduces the vertical structure of developing pine stands. On a short-rotational system, maximum avian diversity may occur in the sapling stage prior to closure of the overstory, but pre-commercial thinning to remove the hardwood understory will prevent a rich avifaunal composition in the sapling stage.

After crown closure, pine stands often reach a successional low-point in avian diversity. Thinning can improve the habitat at this point. If at all feasible, thinning or other timber stand improvement should be done in a random pattern to create patchiness in the stand. Standard row-thinning provides ephemeral stimulation of the understory at best. Stem girdling is a stand improvement practice which may be particularly beneficial to birds.

Pine Forest Types

Jack pine should be maintained on poor sites where it will not be out-competed. Habitat for birds will likely be improved by periodic fires. Conversion of jack pine to a more productive forest type is recommended on better sites. Red pine is often selected to replace jack pine, and it is with red pine that the silvicultural recommendations presented above are most applicable.

Many silvicultural options are available in forests of white pine. Shelterwood and seed tree systems or clearcutting in strips or patches are practices which may provide productive wildlife habitat. White pine may also be managed in uneven-aged stands. On good sites, group selection for white pine in association with management for hardwoods will provide excellent habitat for birds.

Management of pitch pine forests should highlight preservation and the encouragement of occasional fires. Conversion to a non-forested condition is the greatest threat to this forest type, although much pitch pine acreage is currently preserved as state-owned forest land.

KIRTLAND'S WARBLER--AN ENDANGERED SPECIES

The Kirtland's warbler has always been a rare species. Not until 1903 were the nesting grounds found in northern Lower Michigan. Singing males, censused as an index to the nesting population, have declined from 500 in 1961 to 200 in 1971 and have remained at or below that number (Byelich et al. 1976).

The breeding habitat requirements of the Kirtland's warbler are highly specialized (Radtke and Byelich 1963, Byelich et al. 1976). They nest in young stands of jack pine 80 ha or more in size, where homogeneous groups of pine occur in patchy distributions, interspersed with areas of small, grassy openings. The species nests on the ground usually under living pine branches near the ground. Suitable habitat is present only when jack pines are between 2 m and 5 m in height which normally occurs when the trees are 8 to 21 years of age. Preferred nesting habitat is found almost exclusively on a single soil type, Grayling sand.

Byelich et al. (1976) identified two factors which were limiting the population of Kirtland's warblers on the breeding grounds. The primary factor was a reduction in suitable nesting habitat because of fire control and other recent forest practices (Mayfield 1963). A second limiting factor was egg parasitism of Kirtland's warbler nests by brown-headed cowbirds. (Mayfield 1977).

Habitat management for the Kirtland's warbler is the epitome of single-species management, but is dictated by society's concern for a species faced with extinction and, of course, the Endangered Species Act of 1973. Preservation of this species is being carried out in accordance with a recovery plan approved by the U.S. Fish and Wildlife Service (Byelich et al. 1976).

Management of nesting habitat is designed to allow the reestablishment of a self-sustaining population of 1000 pairs of Kirtland's warblers throughout the known former range. The Michigan Department of Natural Resources is currently managing over 30,000 ha of state-owned land for the species, and the Huron National Forest has designated 55,400 ha as Kirtland's warbler habitat (personal communication, Michael T. Mang, William Irvine). These lands are being managed in blocks of 80 to 120 ha, where even-aged stands of jack pine are being regenerated at 10-year intervals. Clearcutting, burning, planting, and seed tree cutting are being used to create the desired habitat. Approximately 25 percent of each block is left in small openings. The management agencies opted to utilize the jack pine for commercial pulpwood thus doubling the total acreage of management blocks and harvesting on a 45 to 50-year rotation.

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Appendix I .--Nomenclature of birds and plants mentioned in the text.

Birds

American woodcock	*Philohela minor*
Mourning dove	*Zenaida macroura*
Yellow-billed cuckoo	*Coccyzus americanus*
Black-billed cuckoo	*Coccyzus erythropthalmus*
Whip-poor-will	*Caprimulgus vociferus*
Common nighthawk	*Chordeiles minor*
Common flicker	*Colaptes auratus*
Pileated woodpecker	*Drycopus pileatus*
Yellow-bellied sapsucker	*Sphyrapicus varius*
Hairy woodpecker	*Picoides villosus*
Downy woodpecker	*Picoides pubescens*
Eastern kingbird	*Tyrannus tyrannus*
G.-crested flycatcher	*Myiarchus cinerascens*
Eastern wood pewee	*Contopus virens*
Olive-sided flycatcher	*Nuttalornis borealis*
Blue jay	*Cyanocitta cristata*
Black-capped chickadee	*Parus atricapillus*
Tufted titmouse	*Parus bicolor*
White-breasted nuthatch	*Sitta carolinensis*
Red-breasted nuthatch	*Sitta canadensis*
House wren	*Troglodytes aedon*
Gray catbird	*Dumetella carolinensis*
Brown thrasher	*Toxostoma rufum*
American robin	*Turdus migratorius*
Wood thrush	*Hylocichla mustalina*
Hermit thrush	*Catharus guttata*
Veery	*Catharus fuscescens*
Eastern bluebird	*Sialia sialia*
Golden-crowned kinglet	*Regulus satrapa*
Ruby-crowned kinglet	*Regulus calendula*

Cedar waxwing	*Bombycilla cedrorum*
Solitary vireo	*Vireo solitarius*
Red-eyed vireo	*Vireo olivaceus*
Black & white warbler	*Mniotilta varia*
Nashville warbler	*Vermivora ruficapilla*
Yellow warbler	*Dendroica petechia*
Magnolia warbler	*Dendroica magnolia*
Yellow-rumped warbler	*Dendroica coronata*
Black-throated green warbler	*Dendroica virens*
Blackburnian warbler	*Dendroica fusca*
Chestnut-sided warbler	*Dendroica pensylvanica*
Pine warbler	*Dendroica pinus*
Kirtland's warblar	*Dendroica kirtlandii*
Prairie warbler	*Dendroica discolor*
Ovenbird	*Seiurus aurocapillus*
Mourning warbler	*Oporornis philadelphia*
Common yellowthroat	*Geothlypis trichas*
Canada warbler	*Wilsonia canadensis*
American redstart	*Setophaga ruticilla*
Scarlet tanager	*Piranga olivacea*
Rose-breasted grosbeak	*Pheucticus ludovicianus*
Purple finch	*Carpidacus purpureus*
American goldfinch	*Carduelis tristis*
Rufus-sided towhee	*Pipilo erythrophthalmus*
Vesper sparrow	*Pooecetes gramineus*
Dark-eyed junco	*Junco hyemalis*
Chipping sparrow	*Spizella passerina*
Field sparrow	*Spizella pusilla*
White-throated sparrow	*Zonotrichia albicollis*
Song sparrow	*Melospiza melodia*

Plants

Eastern white pine	*Pinus strobus*
Red pine	*Pinus resinosa*
Jack pine	*Pinus banksiana*
Pitch pine	*Pinus rigida*
Scotch pine	*Pinus sylvestris*
Balsam fir	*Abies balsamea*
Black spruce	*Picea mariana*
Eastern hemlock	*Tsuga canadensis*
Paper birch	*Betula papyrifera*
Quaking aspen	*Populus tremuloides*
Choke cherry	*Prunus virginiana*
Scrub oaks	*Quercus ilicifolia*
- - -	*Quercus prinoides*
- - -	*Quercus minor*
Blueberry	*Vaccinium angustifolium*
- - -	*Vaccinium vacillans*
Huckleberry	*Gaylussacia baccata*
Wintergreen	*Gaultheria procumbens*
Bracken fern	*Pteridium aquilinum*

Appendix II.-Breeding birds in seral stages of white, red, and jack pine forests.

Descriptive variables	Young jack pine regeneration	Young red pine plantation	Young mixed pine plantation	Pole stage white pine plantation
Year of census	1974	1962	1967	1974
Size of plot (ha)	6.5	4.8	8	7.5
Location	Michigan	Ontario	Ontario	Massachusetts
Habitat				
Stand history	Fire in 1964	Planted in 1950	Reforested agricultural area	Planted in 1933-35
Overstory	Numerous dead snags	None	Scattered hardwoods	White pine dominant (61% cover)
Understory	Young jack pine	Young red pine	Jack, red, scotch, white pines	Scrub oak (5% cover)
Ground cover	Dense	Dense	Dense	Sparse
Edge	Uniform habitat	N/A	Fairly uniform	Uniform habitat
Breeding Birds				
No. species	12	6	31	7
No. territories	12.5	15	62.5	11.5
Territories/km^2	193	312	813	153
Species and no. territories/plot[1]	Brown thrasher 2.5 Vesper sparrow 2 Chipping sparrow 2 Field sparrow 2 E. bluebird 1.5	Dark-eyed junco 4 Vesper sparrow 4 Chipping sparrow 3 American robin 2 Brown thrasher 1	Field sparrow 8.5 Chipping sparrow 5 Song sparrow 3.5 Cedar waxwing 2.5 Purple finch 2	Ovenbird 4 Rufous-sided towhee 2.5 Black-capped chickadee 2 Blue jay 1 Hermit thrush 1
Reference	Munn 1974	MacDonald 1965	Oelke 1967	Lloyd-Evans 1975b

Appendix II.-Continued.

Descriptive variables	Pole stage red pine plantation	Pole/Mature jack pine forest	Mature jack pine forest	Mature white pine forest
Year of census	1962	1971	1974	1967
Size of plot (ha)	4.8	28	12	7
Location	Ontario	Ontario	Minnesota	Ontario
Habitat				
Stand history	N/A	N/A	N/A	N/A
Overstory	Red pine - closed	Jack pine, open and closed	Jack pine dominant (59% cover)	White pine canopy (40-50% cover); diverse subcanopy
Understory	Sparse	Sparse	Moderate	Sparse (5-10% cover)
Ground cover	Sparse	Moderate	Dense (78% cover)	Sparse (5% cover)
Edge	N/A	Uniform habitat	Uniform habitat	Moderate diversity
Breeding Birds				
No. species	1	11	14	27
No. territories	1	25	50	50.5
Territories/km^2	21	88	417	694
Species and no. territories/plot	Yellow-rumped warbler 1	Hermit thrush 4.5 Ovenbird 4 Dark-eyed junco 3.5 Chipping sparrow 3 Yellow-rumped warbler 2.5	Ovenbird 12 Blackburnian warbler 10 Nashville warbler 7 Golden-crowned kinglet 4 Chipping sparrow 3	Blackburnian warbler 4.5 Pine warbler 4 Ovenbird 4 E. wood pewee 3 Wood thrush 3
Reference	MacDonald 1965	Erskine 1971	Niemi 1974	Oelke 1967

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[1] Five most abundant species are listed.

Appendix III.–Breeding birds in seral stages of pitch pine-scrub oak forest. Plots of 7.5 ha were located in uniform habitat, Plymouth Co., Massachusetts (Lloyd-Evans 1973, 1975a, 1977).

Descriptive variables	Stand IV-74 Recent burn		Stand IV-75 Recent burn		Stand III Recent burn	
Year of census	1974		1975		1973	
Habitat:						
Stand history	Burned in May 1974		Burned in May 1974		Burned in May 1971	
Dominant tree (%)	Pitch pine (90)		Pitch pine (72)		Pitch pine (100)	
Dominant understory (%)	Scrub oak (97)		Scrub oak (94)		Scrub oak	
Tree cover (%)	5		5		6	
Dominant ground cover (%)	Oak, seedlings, fern, huckleberry		Huckleberry, wintergreen, blueberry		Huckleberry, blueberry	
Breeding Birds:						
No. species	6		18		13	
No. territories	15.5		33		45.5	
Territories/km^2	207		440		553	
Species and no. territories[1/]	Rufous-sided towhee	6.5	Prairie warbler	10.5	Prairie warbler	9.5
	Hermit thrush	3	Rufous-sided towhee	7.5	Rufous-sided towhee	9
	E. wood pewee	2	Common yellowthroat	2	Common yellowthroat	9
	E. bluebird	2	Brown thrasher	1.5	Field sparrow	5
	Common flicker	1	E. bluebird	1.5	Purple finch	2
	Blue jay	1	House wren	1.5	Brown thrasher	1

Descriptive variables	Stand II Regenerating		Stand V Insect damage		Stand I Mature	
Year of census	1973		1976		1973	
Habitat:						
Stand history	Burned in May 1963		97% of pines killed in 1971		Burned in 1943 or 1944	
Dominant tree (%)	Pitch pine (100)		Pitch pine (100)		Pitch pine (100)	
Dominant understory (%)	Scrub oak		Scrub oak (100)		Scrub oak	
Tree cover (%)	26		4.8		70	
Dominant ground cover (%)	Blueberry, huckleberry		Huckleberry, blueberry		Huckleberry, blueberry	
Breeding Birds:						
No. species	16		22		12	
No. territories	60.5		37.5		52	
Territories/km^2	807		500		693	
Species and no. territories	Prairie warbler	19	Rufous-sided towhee	18	Prairie warbler	16.5
	Rufous-sided towhee	13	Prairie warbler	10.5	Rufous-sided towhee	13
	Common yellowthroat	9	Common yellowthroat	5	Common yellowthroat	11.5
	Field sparrow	3.5	Field sparrow	1.5	Black-capped chickadee	3
	Brown thrasher	3	Hermit thrush	1.5	Field sparrow	2
	Hermit thrush	2	Catbird	0.5	Common flicker	1

[1/] Six most abundant species are listed.

EFFECTS OF SILVICULTURAL PRACTICES ON BIRD COMMUNITIES IN UPLAND SPRUCE-FIR STANDS

Hewlette S. Crawford and Richard W. Titterington[1]

Abstract.--Composition and density of bird populations in upland spruce-fir stands are influenced by the admixture of hardwood with softwoods, the vertical and horizontal structure of the stand, and the extent of spruce budworm infestation of the stand. Silvicultural practices modify all three factors and influence bird populations.

INTRODUCTION

Upland spruce-fir forest types in northeastern and north-central United States and Maritime and southern Canada are largely commercial forests, supporting major wood-using industries. In the United States, most of this forest land is privately owned; in Canada, there is more public ownership. However, in both cases, forest cutting is a major factor that modifies bird habitat structure and influences bird populations.

These commercial woodlands provide the economic base for several states and provinces. Yet the management of these forests is not intensive compared to that in other parts of the continent. Woodland owners and harvesters had enough wood to cut to meet yesterday's needs. However, the situation is beginning to change.

The demand for wood products continues to increase. In the past, industry had the western old-growth forests and the "wood basket" of the South to absorb this demand. Substantial inroads have been made on the old growth and the wood basket is not as deep or productive as once thought. These factors plus competition among the major wood-producing companies will bring intensive forestry to the northern and northeastern coniferous forests, and these practices will have a measurable impact on bird populations.

This paper discusses the effects of silvicultural practices on nongame birds in upland spruce-fir forests.

The major tree species of the upland spruce-fir type are balsam fir (*Abies balsamea*), white spruce (*Picea glauca*), and red spruce (*P. rubens*). Red spruce is limited to eastern portions of the continent, but white spruce is found westward across the continent and balsam fir beyond midcontinent. The transcontinental belt of spruce and fir averages about 300 miles wide (Westveld 1953). Red spruce and balsam fir also grow southward in the higher elevations of the Appalachian Mountains. In West Virginia, balsam fir possibly intergrades with Fraser fir (*A. fraseri*) (Strausbaugh and Core 1964).

Spruce and fir along the northern border of their transcontinental belt are often found in almost pure stands. Intolerant hardwoods such as the birches (*Betula* spp.) and aspens (*Populus* spp.) increase toward the central latitudinal portion of this belt. Along the southern border, midtolerant and tolerant hardwoods such as beech (*Fagus grandifolia*) and maples (*Acer* spp.) compete with spruce and fir for favorable sites.

Although hardwoods are naturally more abundant in the southern portion of the upland spruce-fir type, site characteristics substantially influence their distribution and abundance. Spruce and fir on thin, infertile soils in the moist eastern portion of the range generally grow in dense stands with closed canopies and little hardwood admixture. In an undisturbed state these stands are single-storied with sparse undergrowth. More fertile soils permit more hardwood growth and increased canopy layering. In the more continental climate to the west, hardwoods are better competitors for limited soil moisture, and moisture stress increases the mixture of hardwoods in spruce-fir stands (Westveld 1953).

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BREEDING BIRD COMMUNITIES

The composition and density of bird communities throughout the upland spruce-fir forest are affected by three habitat features: the degree of hardwood admixture with softwoods, the vertical and horizontal stand structure, and the degree of spruce budworm (*Choristoneura fumiferana* Clem.) infestation in the stands. These features can vary considerably from forest stand to forest stand. We also recognize there can be fluctuations in density of bird populations from year to year caused by factors such as winter mortality, migration losses, etc.

The first two features depend on such factors as geographic location, microclimate, site characteristics, and forest management. Spruce budworm infestations appear to be cyclic in nature and are affected by weather and the amount, age, and distribution of balsam fir in the stand.

To describe the relationship between bird populations and forest habitats we analyzed census data from 16 forest stands representing different conditions in upland conifers (Table 1). Cluster analysis was used to express the degree of association or similarity between the bird populations of the 16 stands. We placed each of the 16 bird censuses into one of six groups based on the similarity of their bird species composition (Fig. 1, Table 2):

Balsam fir stands (censuses 1 and 2)
Mature spruce stands (censuses 5,6,7,8, and 9)
Mixed growth stands (censuses 14,15, and 16)
Spruce-fir stands with budworm (censuses 3 and 4)
Spruce-fir stands without budworm (censuses 12 and 13)
Young spruce stands (censuses 10 and 11)

Balsam Fir Stands

In the two balsam fir stands, this species dominated the overstory trees. The stand located near Lake Winnipegosis, Manitoba (Erskine 1972), was characterized by a two-tier overstory with a dominant canopy (about 17 m tall) of fir and paper birch and a subcanopy (about 9.5 m tall) of fir, birch, and quaking aspen (*P. tremuloides*). The stand located in west-central Saskatchewan (Erskine 1973) was characterized by dense, immature growth of balsam fir (9 to 12 m tall) and small numbers of mature fir, spruce, aspen, and birch scattered throughout (up to 25 m tall).

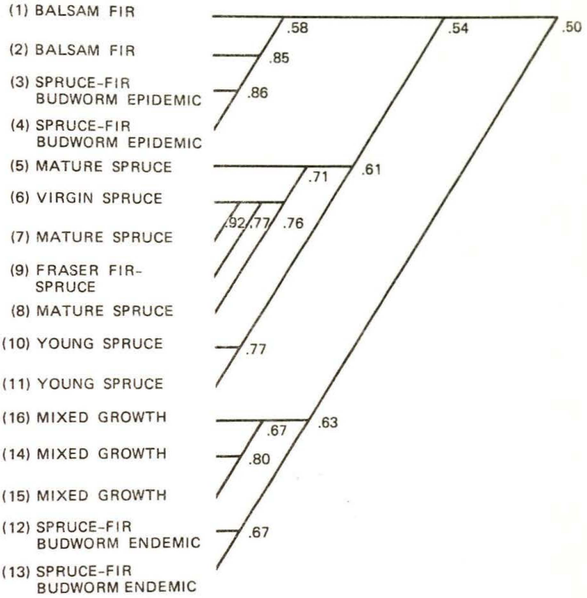

Figure 1.--Cluster diagram of forest plots based on bird species composition. Similarity indices are shown at connecting points.

The balsam fir stands supported an impoverished avifauna with an average of only 128 pairs/40 ha and 20 bird species. The four dominant bird species were the Swainson's thrush (*Catharus ustulata*) and magnolia (*Dendroica magnolia*), black-throated green (*D. virens*), and bay-breasted (*D. castanea*) warblers. The Swainson's thrush and magnolia warbler were associated with the immature balsam fir.

Qualitatively, the two balsam fir stands were similar in bird species composition to the budworm infested spruce-fir stands (Table 2). The presence of Tennessee (*Vermivora peregrina*) and bay-breasted warblers, species closely associated with spruce budworm, was probably a result of spruce budworm populations.

Table 1.--Summary of bird censuses used in analyses of bird communities in upland conifers

Census no.	Forest type	Location	No. of species	Pr/ 40 ha	Source
1	Balsam fir forest	Manitoba	20	112	Erskine (1972)
2	Balsam fir forest	Saskatchewan	19	145	Erskine (1973)
3	Spruce-fir forest budworm epidemic	Ontario	36	319	Kendeigh (1947)
4	Spruce-fir forest budworm epidemic	Maine	31	350	Stewart and Aldrich (1952)
5	Mature 2nd-growth spruce	New Hampshire	21	235	Titterington (Unpubl. data)
6	Virgin spruce forest	West Virginia	28	325	Stewart and Aldrich (1949)
7	Mature 2nd-growth spruce	West Virginia	23	295	Stewart and Aldrich (1949)
8	Mature red spruce forest	Vermont	20	217	Nichols (1968)
9	Mature Fraser fir-spruce	West Virginia	23	247	Hutton et al. (1968)
10	Young spruce	West Virginia	19	278	Stewart and Aldrich (1949)
11	Young spruce	West Virginia	15	220	Sigel et al. (1968)
12	Spruce-fir forest budworm endemic	Ontario	24	249	Martin (1960)
13	Spruce-fir forest budworm endemic	Ontario	28	131	Sanders (1970)
14	Spruce-fir-aspen-birch, mixed growth	Ontario	22	159	Martin (1960)
15	Spruce-fir-hardwood, mixed growth	Ontario	27	258	Martin (1960)
16	Balsam fir-birch forest, mixed growth	Minnesota	23	276	Niemi (1972)

Mature Spruce-Fir with Epidemic Spruce Budworm Populations

Dominant spruce and fir with overmature and dying trees, a midstory of balsam fir, and an open shrub understory botanically characterized these stands (Kendeigh 1947, Stewart and Aldrich 1952). The characteristic biological features were an ongoing spruce budworm infestation and high densities of breeding birds (Morris et al. 1958). The budworm areas supported 1.75 times as many pairs/40 ha as similar stands with endemic budworm populations (334 pairs/40 ha compared to 190/40 ha). Three warbler species, the Tennessee, Cape May (*D. tigrina*) and bay-breasted, were abundant in the budworm areas but absent from non-budworm areas (Table 2). These three species show strong positive numerical responses to spruce budworm outbreaks (Morris et al. 1958).

Spruce-Fir with Endemic Spruce Budworm Populations

Balsam fir predominated in these stands and white and black (*P. mariana*) spruce also were significant in the overstory. The overstory had a clumped distribution with several shrub species occupying the openings. Sanders (1970) found intolerant hardwoods in the overstory but Martin (1960) did not. Average heights of overstory trees were about 10 and 15 m in Sanders' and Martin's areas, respectively.

The magnolia warbler was the dominant species; yellow-rumped warblers (*D. coronata*) and golden-crowned kinglets (*Regulus satrapa*) were abundant in the overstory canopy. White-throated sparrows (*Zonotrichia albicolis*) and chestnut-sided warblers (*D. pensylvanica*), both common species, were found in the shrubby openings.

Table 2.--Density of bird populations, by species and forest type (in pairs per 40 ha: o = absent; + = <5; * = 5 to 10; ** = 11 to 25; *** = >25)

Species	Balsam fir	Mature spruce	Mixed growth	Budworm spruce-fir	Non-budworm spruce-fir	Young spruce 15-30 ft tall
Yellow-bellied sapsucker	o	o	*	+	+	o
Black-capped chickadee	o	+	*	+	+	*
Boreal chickadee	+	+	o	*	+	+
Red-breasted nuthatch	+	*	+	*	+	*
Brown creeper	o	+	o	+	o	o
Winter wren	*	+	+	+	+	**
American robin	o	+	+	+	+	**
Wood thrush	o	+	+	o	o	o
Hermit thrush	o	*	+	+	+	+
Swainson's thrush	**	*	+	**	+	**
Veery	o	+	*	+	o	+
Golden-crowned kinglet	o	***	+	*	**	*
Solitary vireo	+	**	o	*	o	o
Red-eyed vireo	+	+	***	*	+	o
Black-and-white warbler	o	o	**	o	*	o
Tennessee warbler	*	o	o	***	o	o
Nashville warbler	o	o	**	*	*	o
Magnolia warbler	**	***	**	***	***	***
Black-throated blue warbler	o	**	+	+	o	o
Cape May warbler	o	o	o	***	o	o
Yellow-rumped warbler	*	*	+	**	**	o
Black-throated green warbler	**	**	*	+	o	+
Blackburnian warbler	+	***	**	**	+	+
Chestnut-sided warbler	o	o	*	o	**	+
Bay-breasted warbler	**	o	o	***	o	o
Ovenbird	+	+	***	*	*	o
Canada warbler	*	*	**	+	o	o
Purple finch	o	*	+	+	+	*
Dark-eyed junco	o	***	o	*	+	***
White-throated sparrow	*	*	*	**	***	o
$\bar{X}$ pairs/40 ha	128	264	231	334	190	249
$\bar{X}$ species	20	23	24	34	26	17

Mature Spruce

The mature spruce stands were second growth except for one virgin stand with a considerable tolerant hardwood component. The virgin stand (Stewart and Aldrich 1949) was essentially one-storied with a sparse scattering of understory trees and shrubs. Second-growth stands were mature and contained large trees, dense closed canopies, and scattered openings with shrubs and saplings. The canopy of one stand (Hutton et al. 1968) was nearly 50 percent Fraser fir and 35 percent red spruce. Canopies in the other stands were 60 to 90 percent red spruce (Stewart and Aldrich 1949, Nichols 1968, Titterington unpubl. data). The Fraser fir stand grouped with mature spruce because the fir were unusually large trees--up to 48 cm dbh. Few balsam fir reach this size and tree size seems to be a determinant in bird populations.

These stands supported almost as many birds as the budworm-infested stands. The most abundant birds were the canopy gleaners--blackburnian warbler (*D. fusca*) and golden-crowned kinglet in the upper canopy; solitary vireo (*Vireo solitarius*), magnolia, black-throated blue (*D. caerulescens*) and black-throated green warblers in the mid- to lower canopy; and dark-eyed junco (*Junco hyemalis*) on the open forest floor. The mature spruce stands supported more than twice as many birds as the balsam fir stands, an average of 264 pairs/40 ha compared to 128 for balsam fir. Several factors may account for this substantial difference. Spruce are long lived, commonly grow taller (USDA 1965), and develop greater canopy depth than balsam fir. Spruce express dominance and provide more heterogeneous horizontal and vertical stand structure than is found in fir stands. We believe spruce stands with more foliage and limb area than fir stands support greater populations of endemic insects that are valuable as food for foliage-gleaning birds.

These bird species have adapted to divide the feeding zones and more efficiently use the mature crowns (MacArthur 1958).

Young Spruce Stands

A dense, uniform canopy of > 90 percent red spruce dominated the habitat structure of the young spruce stands. Tree heights averaged 4.5 m in one stand (Stewart and Aldrich 1949) that had a dense understory of mountain laurel (*Kalmia latifolia*), and 9 m in the other stand (Sigel et al. 1968) that was quite open underneath.

These stands supported an average of 249 pairs/40 ha of breeding birds though the young stands averaged only 17 bird species compared with an average of 23 in the mature stands. The dominant bird species were the magnolia warbler and the dark-eyed junco; both species were also common in mature spruce stands (Table 2), but their densities were twice as high in the young stands as in the mature. While the magnolia warbler is a characteristic species of the upland conifer forest, it is most populous in dense, young developing conifer stands. Dark-eyed juncos nest and forage on the ground as well as in coniferous shrubs and saplings. Both species benefit from the protective cover common in these stands.

Although sparse in mature stands, the Swainson's thrush, winter wren (*Troglodytes troglodytes*), and American robin (*Turdus migratorius*) were common in young spruce stands. The two thrushes were probably attracted to the dense saplings and pole-size softwoods. The winter wren's response to habitat features is similar to that of the dark-eyed junco.

Virtually absent from the young spruce stands were high canopy, foliage-gleaning bird species such as the golden-crowned kinglet and blackburnian and black-throated green warblers.

Mixed Growth Stands

Two of the stands (Martin 1960, Niemi 1972) contained intolerant hardwoods from 12 to 18 m tall, overtopping fir. One stand (Martin 1960) had tolerant hardwoods from 18 to 24 m tall, overtopping fir. Heights of fir ranged from 9 to 12 m. The understory in all stands consisted of a dense growth of shrubs and tree seedlings and saplings.

Red-eyed vireos (*V. olivaceous*) and ovenbirds (*Seiurus aurocapillus*) were the dominant species. Birds usually associated with hardwoods and common in these mixed growth stands were black-and-white (*Mniotilta varia*), Nashville (*V. ruficapillus*), and Canada (*Wilsonia canadensis*) warblers. Yellow-bellied sapsuckers (*Sphyrapicus varius*) were more common in this forest type than in any other. Other common species attracted to the softwoods were the magnolia and blackburnian warblers. Other species that frequent high canopy conifers were sparse or absent.

These stands supported an average of 231 pairs/40 ha, slightly less than were supported by mature spruce stands. Numbers of species were about the same as in mature spruce stands (Table 2).

SILVICULTURE AND BIRD HABITAT

Spruce and fir are tolerant and can be successfully managed with even-age or uneven-age silviculture. Seed-tree systems are not suitable because shallow rooting makes these tree species susceptible to windthrow.

Silvicultural practices modify forest stands by changing plant species composition and the vertical and horizontal structure of vegetation in the stand. Plant composition and structure are the base elements of bird habitat. Many studies have shown that bird populations respond to changes in their habitat (Hagar 1960, Haapanen 1965, Titterington et al. 1979).

We can scale stand modification from "light" (uneven-age silviculture) to "heavy" (clearcutting, followed by site preparation and planting). Between these limits lie many different silvicultural practices. Effects on bird populations differ along this approximate continuum according to the degree of habitat modification (Table 3).

Also, after any disturbance--including that caused by cutting--the patterns and timing of secondary plant succession vary with the geographic location, availability of seed, microclimate, site, and the degree of disturbance.

The successional patterns of bird species in upland coniferous forests are closely related to the plant succession that follows habitat disturbances (Titterington et al. 1979). Each seral stage is characterized by a group of associated bird species.

The following discussion is based primarily on data collected in commercially clearcut spruce-fir forests of northern Maine (Titterington et al. 1979), and on our findings in Maine upland spruce-fir stands. The response by habitat-related groups of bird species to different habitat features should be similar throughout the upland spruce-fir type. Species

Table 3.--The response of birds to habitat modification, by bird habitat group, response time, and silvicultural treatment (A = abundant in species and density; C = common; R = regular; 0 = occasional)

Response time (years)	Treatment							
	Uneven-age	Large diam-limit	Thinning sawlogs	Thinning poles	Shelter-wood cut	Commercial clearcut & small diam. limit	Silvi-cultural clearcut	Cut, site preparation, & plant
				UPPER CANOPY GROUP				
0 to 5±	A	R	R	R	C	R-0	0	0
5 to 30±	A	R	C	C	0	R-0	0	0
30 to 100±	A	C	--	A-C	C-R	R-0	C	C
				LOWER CANOPY GROUP				
0 to 5±	A	R	R	C	C	R-0	0	0
5 to 30±	A	R	C	C	0	R-0	R	R
30 to 100±	A	C	--	A-C	C-R	R-0	C	C
				SHRUB-SAPLING GROUP				
0 to 5±	R	0	0	R	0	R-0	R-0	0
5 to 30±	R	0	R-0	R-0	C	A-C	A-C	C-R
30 to 100±	R	0	--	0	R	R-0	0	0
				BRAMBLE-HERBACEOUS GROUP				
0 to 5±	0	0	0	0	0	A-C	A	R-0
5 to 30±	0	0	R-0	R-0	C	R-0	R-0	R-0
50 to 100±	0	0	--	0	R	0	0	0
				SLASH-OPEN GROUND GROUP				
0 to 5±	R	R	R-0	0	A-C	A-C	A	0
5 to 30±	R	R	R	R	R	0	0	0
30 to 100±	R	R	--	R	R	R	R	R
				CAVITY NESTING GROUP				
0 to 5±	0	R	R-0	R-0	0	R	R-0	0
5 to 30±	0	R	R-0	R-0	0	R	0	0
30 to 100±	0	R	--	R	0	R	0	0

of birds within the habitat groups may differ because of restricted geographic ranges or different proportions of conifers and hardwoods.

Uneven-Age Silviculture

A well-planned system of single tree or small group selection maintains an uneven-aged stand and, among harvest methods, comes closest to retaining a continuous cover of trees of many ages and heights. Vertical development is at a maximum (Frank and Bjorkbom 1973), which provides more canopy layers than any other silvicultural system. Horizontal diversity is maintained through a mosaic of different sites--resulting largely from glaciation--which form brushy bogs and swamps, blowdown openings, localized natural tree mortality, and localized type anomalies.

At short intervals, mature trees are removed as scattered individuals or small groups to provide a sustained yield of products, even from relatively small ownerships. Competing hardwoods and noncrop softwoods are thinned and weeded at the same time. The time between cuttings on a given area may range from 10 to 25 years, depending on the site and on economic considerations (Frank and Bjorkbom 1973). By frequent harvest cuts, trees that might otherwise die are cut, thus well-managed stands will not have as many standing dead trees.

Bird populations remain more stable with uneven-age than with even-age silviculture. Managed uneven-aged stands at any given time have a greater variety of habitat strata than unmanaged mature spruce stands. Numbers of bird species and densities of individuals would likely equal or exceed the levels found in the mature stands, although there would be fewer mature trees so the upper canopy would not support as many birds. The numbers of golden-crowned kinglets and blackburnian warblers would be less. However, the well-distributed canopies of the low and midstory trees should support more low canopy species such as the magnolia and yellow-rumped warbler, Swainson's thrush, and the solitary vireo, with an overall increase in numbers. Ground-feeding species such as the dark-eyed junco and white-throated sparrow will be found in small openings. Cavity nesters may be adversely affected.

Even-Age Silviculture

Harvest Cuttings

Clearcutting.--Silvicultural clearcutting is the felling of all stems greater than 2.5 to 5.0 cm in diameter at breast height (dbh). This type of cutting should be done only if advance reproduction or a seed source is available or if the area is to be replanted immediately. It is often advantageous to cut in small patches or narrow strips to facilitate natural seeding. Where environmental conditions are not too severe, the openings should be wider than one tree height and no wider than 25 to 30 m for balsam fir and 55 to 60 m for red and white spruce. Where there is danger of seedling dessication or wind damage, the openings should be no larger than half the height of the trees in the stand. Uncut areas should be at least 10 m wide (Frank and Bjorkbom 1973).

In the upland spruce-fir forest ecosystem, plant succession has five seral stages that follow severe disturbances such as clearcutting (Titterington et al. 1979), and each is characterized by one or more habitat feature: (1) open ground-slash--abundant open ground and dense slash; lasts from 0 to 2 years after disturbances; (2) bramble-herbaceous--dense low layer of brambles and herbaceous plants with scattered small regenerating tree species; lasts 3 to 10 years after disturbances; (3) shrub-sapling--dominated by hardwood and softwood regeneration taller than 2 m; lasts 4 to 20 years after a disturbance; (4) immature second growth--pole-size hardwoods and/or softwoods 10 to 20 cm dbh; lasts from 20 to 50 years after disturbances; (5) mature second growth--dominated by softwood > 20 cm dbh; lasts from 40 to 80 years after disturbances.

Avifaunal succession is directly related to these seral stages. Bird species that nest and forage predominantly on the ground, such as the white-throated sparrow, dark-eyed junco, and winter wren, are closely associated with the first seral stage. The slash commonly left after tree harvesting provides important protective cover for these bird species.

Bird species adapted to nest and forage in dense vegetation close to the ground are closely associated with the second seral stage. The white-throated sparrow, common yellowthroat (*Geothlypis trichas*), chestnut-sided warbler, and mourning warbler (*Oporornis philadelphia*) all reach their highest densities in this habitat. The edges, with a dense growth of brambles, will also be used by these species.

Bird species, such as the white-throated sparrow, magnolia warbler, red-eyed vireo, American redstart (*Setophaga ruticilla*), and Canada warbler are abundant nesters and foragers in the dominant shrub-sapling stratum of the third seral stage. The white-throated sparrow and black-and-white warbler both nest on or near the ground, but spend a large part of their foraging time in saplings.

The substantial lower and midcanopies characteristic in the fourth seral stage provide abundant foraging sites for such species as the solitary vireo, Swainson's thrush, rose-breasted grosbeak (*Pheucticus ludovicianus*), black-throated blue warbler, Tennessee warbler, and the ovenbird. These last three species nest on or near the ground.

The dominant bird species of the fifth seral stage, such as the golden-crowned kinglet, yellow-rumped, black-throated green, bay-breasted, Cape May, and blackburnian warblers, satisfy their foraging and nesting requirements in the upper canopy.

Clearcutting for natural regeneration affects bird populations in proportion to the minimum size of stems cut and the size of areas cut. Upper and lower canopy habitats are eliminated with silvicultural clearcutting, but the understory is retained and a slash habitat may be created. Depending on site quality, in 2 to 4 years, the regenerating trees, herbs, and raspberries increase the understory density and provide habitat for the common yellowthroat, white-throated sparrow, and associated species. When stems 8 to 16 cm dbh are left uncut, some shrub-sapling and lower canopy birds such as the magnolia warbler and its associates will continue to find favorable habitat as will some cavity nesting species. However, this will lessen the understory growth with a resulting decrease in the number of understory birds. Site quality and subsequent thinning will determine the rate at which lower and upper canopies develop and provide habitat for canopy species.

Unlike large cleared areas, small clearcuts--from 2 to 8 ha (5 to 20 acres)--result in different aged stands and a greater variety of bird species found in close proximity at any one time. Long rotations, which result in increased crown development and stand size variety, enhance habitat for more bird species than short rotations regardless of the type of harvest system used in even-age silviculture.

Shelterwood.--Clearcutting small areas can be considered a shelterwood cut if the clearings are less than one-half the height of the trees in the stand. In shelterwood systems, a first harvest is made to establish reproduction and one or more later harvests remove the remaining stand when the regeneration no longer needs protection from wind and excessive insolation (Frank and Bjorkbom 1973).

Shelterwood methods cause the least drastic stand modification of the even-age silvicultural regeneration systems. When the overstory is removed in two or more operations at intervals of 5 to 25 years, the effects on birds are similar to group selection, especially if more than two cutting stages are used. When the last cut removes the remaining overstory, advanced reproduction is well established. Upper and lower canopy birds lose their habitat but shrub and sapling birds such as the magnolia warbler, and bramble-herbaceous birds such as the common yellowthroat, find improved habitat. Species such as the dark-eyed junco will be found in a dominant stratum of slash left after heavy cutting. The slash and shrub-sapling strata diminish with time as tree crowns increase in height and volume, which provides favorable conditions for low canopy species. Eventually the dominant trees again provide habitat favorable for both lower and upper canopy species. Cavity nesters would find little habitat after the final removal cut.

Planting and Seeding

Clearcutting followed by site preparation, planting, and control of competing vegetation causes the greatest disruption of upland spruce-fir stands.

Planting or seeding may be advantageous where natural regeneration is lacking or will take several years to develop, or where the better sites warrant planting superior stock. Competing vegetation and debris may be removed by mechanical means, chemical treatment, or controlled burning before planting or seeding. Generally these treated areas are substantially exposed.

The use of the area by birds would be inversely related to intensity of the practices employed. Heavy slash left in clearcut areas is used by dark-eyed juncos and winter wrens for foraging and nesting. Woodpeckers also forage in slash (Conner and Crawford 1974). When slash is eliminated, the area has little to attract these bird species.

If small seedlings are planted and competing vegetation is controlled, it may be 5 or more years before the area is suitable for species attracted to the shrub-sapling stratum. Depending on the amount of revegetation, some use of the area would probably be made by species such as the Savanna sparrow (*Passerculus sandwichensis*) that nest in open fields. Because plant succession is slower on poor sites, the length of time before shrub-sapling bird groups reoccupy the site may be longer than on better sites. For bird rehabitation, a favorable alternative would be closely spaced plantings of superior growing stock on better sites, with minimum vegetation control, and with slash left in place. The period of time that areas are unsuitable for birds would then be minimized.

Intermediate Cuttings

Even-age silvicultural systems require cultural treatments between harvest cuts to help the stand develop properly.

"Cleanings" done in sapling stands release and increase the growth of potential crop trees by removing nearby competing stems. Cleanings generally remove hardwood from spruce and fir on sites with deep, well-drained soils about 8 years after harvest. Cleanings may be done by cutting or by chemical treatment.

"Thinning" removes trees that compete with crop trees or those that may die before regeneration cuts are due, and speeds up the growth of the residual trees. It is conducted in pole-size and sawlog-size stands (Frank 1973). These cuts may remove 10 to 50 percent of the basal area, depending on the site.

After intensive thinning of hardwood and softwood species in pole-size spruce-fir stands, there is a decrease in use by upper canopy birds; removing softwood trees particularly affects nesting conditions. However, such thinning favors habitat use by lower canopy species.

Intensive thinning in sawlog-size stands releases hardwood understory and herbaceous ground cover, and increases use by shrub-sapling and lower canopy birds; upper canopy species continue to be represented. Continued growth of the hardwood understory creates favorable conditions for ovenbirds; black-throated green, black-throated blue, and Canada warblers; Swwinson's thrush; and rose-breasted grosbeaks. Cavity nesters are adversely affected by thinning such stands unless trees are killed and allowed to remain standing.

Intermediate cuttings decrease the number of hardwood trees in sapling spruce-fir stands during cleaning operations, which results in less use of the area by the black-and-white and Canada warblers, the red-eyed vireo, the American redstart, and associated species. If the weeding is intensive enough to cause a dense herbaceous growth, this benefits the common yellowthroat and associated species, and it might favor the dark-eyed junco and associated species if the hardwood slash is left.

Forest stands located on good sites respond to thinning more rapidly than stands on poor sites. Consequently, the alteration of habitat on good sites effects changes in bird species representation more quickly and for a shorter time.

Unregulated Methods

Commercial clearcutting and diameter-limit cutting usually remove the largest and best trees from a stand, which results in high grading. The size and quality of stems harvested are usually determined by marketing conditions. These cutting methods are not designed to provide regeneration, but may do so; neither do they generally provide for any cultural treatments. Intensity of harvest may vary from light removal of large trees from old-growth stands to removal of all spruce and fir except culls and saplings.

Large diameter limit harvests do not maintain a proper distribution of tree size classes through thinning. Vertical canopy development would not be as great as in managed uneven-aged stands. Distribution of trees in the lower canopy would be left to chance and the number and density of bird species would be correspondingly less than in managed uneven-aged stands. Habitat for cavity nesters would be favorable because cull trees are left standing.

Small diameter limit cuts and commercial clearcutting open the stand to varying degrees depending on the number of saleable trees. This cutting does not remove stems in the lower size classes, and shrub-sapling and low canopy strata usually are not reduced. Many birds frequenting these habitats remain, or possibly increase, due to increased vegetative growth. If understory vegetation is poorly developed, stands are of less value to birds. Noncommercial or cull overstory trees are left which provide a variable amount of habitat for upper canopy species. Habitat for cavity nesters can be favorable.

SUMMARY

Five seral stages with corresponding bird species succession follow severe disturbance in upland spruce-fir forests:

(1) Open ground-slash--white-throated sparrow, dark-eyed junco, and winter wren.

(2) Bramble-herbaceous--white-throated sparrow, common yellowthroat, chestnut-sided warbler and associates.

(3) Shrub-sapling--white-throated sparrow, magnolia warbler, red-eyed vireo and associates.

(4) Immature second growth--solitary vireo, Swainson's thrush, black-throated blue warbler and associates.

(5) Mature second growth--golden-crowned kinglet, blackburnian warbler, yellow-rumped warbler and associates.

In forest stands, the composition and density of bird communities is affected by the admixture of hardwoods with softwoods, vertical and horizontal stand structure, and degree of spruce budworm infestation in the stands. Based on number of bird species present and population density, we separated forest stands as follows:

Stand	Pairs/40 ha	No. species
Balsam fir	128	20
Mature spruce	264	23
Mixed growth	231	24
Spruce-fir w/budworm	334	34
Spruce-fir no budworm	190	26
Young spruce	249	17

Silvicultural practices modify stands by changing plant composition and vertical and horizontal stand structure. To meet their nesting and foraging requirements, bird populations respond by utilizing the habitat to which they are best adapted.

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BIRD COMMUNITIES ASSOCIATED WITH SUCCESSION AND MANAGEMENT OF LOWLAND CONIFER FORESTS

Deanna K. Dawson[1]

Abstract.--Data from published bird censuses were used to determine changes in avian communities in relation to plant succession, fire, type conversion, and timber management practices in lowland conifer forests in the northeastern United States. With modifications in current logging practices, habitat for the bird species that nest in undisturbed stands can be provided. Management guidelines are recommended.

INTRODUCTION

Lowland conifer forests comprise over five million acres of the commercial forestland in the northeastern United States, and an even larger area of the type has been classified as noncommercial because of stunted and sparse timber growth. This paper deals with the northern lowland conifer communities, in which tamarack (Larix laricina), black spruce (Picea mariana), or northern white-cedar (Thuja occidentalis) are dominant. These forests have long been of interest to botanists because of the presence of insectivorous plants and numerous species of orchids, but the avian communities have received much less attention. Communities of birds associated with different successional stages will be identified, and guidelines will be discussed for making timber management practices compatible with the maintenance of avian habitat. Other lowland conifer species not considered here are Atlantic white-cedar (Chamaecyparis thyoides) which grows in a narrow belt along the Atlantic coast as far north as southern Maine, and loblolly pine (Pinus taeda) which grows on the Coastal Plain and Piedmont from Delaware south.

METHODS

Little study has been conducted on avian populations in lowland conifer stands. In order to identify the bird species associated with different successional stages, I drew together information from several sources. For information on species abundance, I relied mainly on Breeding Bird Censuses conducted in the northeastern United States and Canada (Audubon Field Notes 1959-1970; American Birds 1971-1977) and on other studies which used the same census technique (International Bird Census Committee 1970). These include studies by Brewer (1967), Kendeigh (1948), Martin (1960), Stewart and Aldrich (1952), and a study in progress on the Seney National Wildlife Refuge in Upper Michigan by the Migratory Bird and Habitat Research Laboratory, USDI Fish and Wildlife Service. Censused plots were grouped into six different lowland communities following Erskine (1977). Density figures were calculated based on the mean number of territorial males per 40 hectares on plots where each species was recorded. I also referred to regional references on birds, such as Roberts (1932) and Palmer (1949), and read the chapters in Bent's life history series (Bent 1937, 1938, 1939, 1942, 1953, 1968) to fill in when information on a species was scant. Since no density figures were available, I evaluated only whether these species would commonly be found. All these sources were also used as the basis for determining the effect of timber management practices on birds.

THE LOWLAND CONIFER FORESTS

Most of the lowland conifer forests in the northeastern United States are growing on organic soils or peat. Some of these peatlands have developed with the buildup of encroaching vegetation in small lakes and depressions left by glacial activity. Sedges and sedgelike plants grow toward the center of the basin from the shore, forming a floating mat of vegetation. Other peatlands formed with the accumulation of reed-sedge debris in poorly drained glacial lakebeds. The bog community becomes established as sphagnum moss and ericaceous shrubs invade the sedge mat. Tamaracks are generally the first trees to appear, and peat compressed by the weight of the sphagnum and increased shrub growth also provides a favorable seedbed for black spruce. With continued buildup of organic material and a lowering of the water table, a dense spruce forest can develop. If the peat has become consolidated and firm, northern white-cedar may slowly invade the lowland conifer forest.

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The young cedars that become established can spread by vegetative reproduction, and eventually can prevent shrub growth and further regeneration of tamarack and black spruce. In most cases, shade-tolerant balsam fir (Abies balsamea) is the only other tree species to become established (Curtis 1959, Johnston 1972, Martin 1959). White pine (Pinus strobus) and deciduous species are found growing with northern white-cedar in the transition to uplands. The range of the lowland conifer species is shown in Figure 1. In the southernmost parts of the range, tamarack occurs in pure stands or in association with lowland hardwood species such as red maple (Acer rubrum).

Common Plants of the Open Bog

Shrubs

- Bog birch (Betula pumila and glandulosa)
- Bog laurel (Kalmia polifolia)
- Bog rosemary (Andromeda glaucophylla)
- Cranberry (Vaccinium macrocarpon)
- Labrador Tea (Ledum groenlandicum)
- Leatherleaf (Chamaedaphne calyculata)

Herbs

- *Bladderwort (Utricularia sp.)
- *Pitcherplant (Sarracenia purpurea)
- *Round-leaved sundew (Drosera rotundifolia)
- Cottongrass (Eriophorum angustifolium)
- Bog buckbean (Menyanthes trifoliata)
- **Arethusa (Arethusa bulbosa)
- **Grass pink (Calopogon pulchellus)
- **Rose pogonia (Pogonia ophioglossoides)

* insectivorous plants ** orchid species

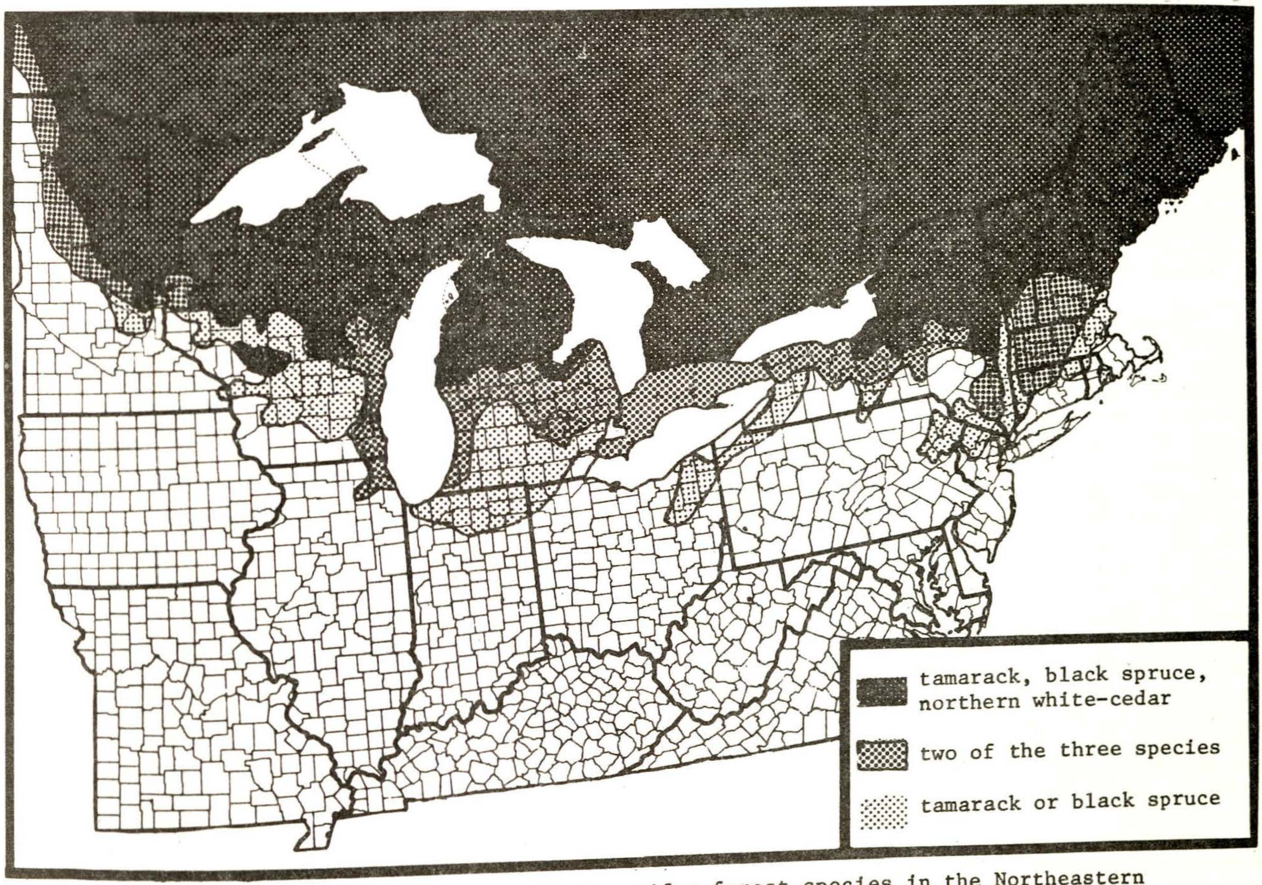
▆ tamarack, black spruce, northern white-cedar
▩ two of the three species
░ tamarack or black spruce

Figure 1.--Ranges of the northern lowland conifer forest species in the Northeastern United States. All species also occur farther south in isolated areas of the Appalachian Mountains and throughout most of Canada (Little 1971).

BIRDS OF LOWLAND CONIFER COMMUNITIES

Breeding birds of six different lowland conifer communities are shown in Table 1.[2/] Several species (designated with an asterisk) are only locally common (such as the Gray Jay and Northern Waterthrush) and may be found in high densities in some areas but absent in similar habitat within their breeding range. The breeding ranges of other species (e.g. Wilson's and Palm Warblers) extend southward only to the northernmost United States, and consequently these birds will not be present in most lowland conifer stands. Differences in breeding ranges also account for the absence of Connecticut Warblers in bogs in New England and Blackpoll Warblers in mature spruce forests in the North Central states. Other species have specific habitat requirements that preclude their nesting in most stands. Sharp-tailed Grouse have only been found in the extensive areas of open bog and scattered low conifers (Hanson 1953), such as those in northern Minnesota or Upper Michigan. Savannah Sparrows are common only in bogs with large open patches of grasses and sedges.

Although several species, such as the Spruce Grouse, Yellow-bellied Flycatcher, Palm Warbler, Northern Waterthrush, and Lincoln's Sparrow, are more common and reach higher densities in these habitats, neither these nor any other characteristic species are unique to these forest types. Birds of the open bog-shrub community can also be found nesting in alder thickets or in the shrubby growth along lakes and streams. Likewise, a mature black spruce stand has an avian community similar to an upland spruce-fir forest.

The avian community of a stand in which tamarack is dominant includes bird species common in shrubby areas as well as species generally associated with hardwood forests. Tamarack, though a conifer, is deciduous; during late fall and early spring when needles are absent, the increased sunlight reaching the forest floor stimulates shrub growth. Even during the summer months, the fine needles and relatively open canopy cast little shade, so that mature tamarack stands generally have a much denser understory than mature spruce or white-cedar forests. At the time many of the birds are arriving in the spring, tamarack swamps resemble hardwood forests more than lowland conifer stands. Though few northern white-cedar stands have ever been censused, high densities of Northern Parulas and Black-throated Green Warblers make the avian community distinct.

If trees are killed by fire, high water, insects, or disease, woodpeckers and Brown Creepers may come in to forage for insects on snags and downed timber. The Black-backed Three-toed Woodpecker in particular is likely to be found in areas in which there are many standing dead trees. In addition, there are twenty species of birds that may nest in cavities in dead or dying trees.

Cavity-nesting Birds of Northern Bogs and Coniferous Forests

Common Goldeneye
Common Merganser
Red-breasted Merganser
Hooded Merganser
American Kestrel
Saw-whet Owl
Yellow-shafted Flicker
Pileated Woodpecker
Yellow-bellied Sapsucker
Hairy Woodpecker
Downy Woodpecker
Black-backed Three-toed Woodpecker
Northern Three-toed Woodpecker
Great Crested Flycatcher
Tree Swallow
Black-capped Chickadee
Boreal Chickadee
Red-breasted Nuthatch
House Wren
Starling

During outbreaks of insect pests, populations of certain bird species have been shown to increase. Though the spruce budworm (Choristoneura fumiferana) mainly attacks balsam fir and white spruce (Picea glauca), it can maintain itself over a period of years on black spruce (Blais 1957). Kendeigh (1947) and Morris et al. (1958) reported strong increases in densities of several warbler species, particularly the Bay-breasted and Tennessee Warblers, in response to outbreaks of the spruce budworm in spruce-fir forests. Buckner and Turnock (1965) found the fringillids (grosbeaks, finches, and sparrows) to be more important than the warblers as predators of the larch sawfly (Pristiphora erichsonii) in tamarack bogs. Small flocks of nonresident avian species were also observed foraging in areas of high sawfly densities.

Though few hawks and owls have been recorded in censuses of lowland conifer stands, several species of raptors do nest in and use these habitats. Roberts (1932) reported nesting of the Sharp-shinned Hawk, Broad-winged Hawk, Great Horned Owl, and Long-eared Owl in conifer swamps in Minnesota. The few nesting records of the Great Gray Owl in the northeastern United States have been in tamarack bogs (Roberts 1936, Nero 1970), and Nero et al. (1974) also reported the successful occupancy by this species of an artificial nest placed in a tamarack tree. Keran (1978) pointed out the need for a variety of habitat types by nesting Broad-winged Hawks. Although oak-aspen was the preferred forest type, the presence of a wet area and some type of upland

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[2/] Scientific names in Appendix.

Table 1.--Abundance of breeding bird species found in various stages of lowland conifer succession.[1]

Bird Species	Dominant Plants					
	Open bog-low shrubs (4)[2]	Shrubs, scattered conifers (13)	Young or low Black Spruce (2)	Medium-mature B.Spruce (5)	Tamarack (3)	Northern White-cedar (3)
American Bittern	U[3]					
Sora	U					
Killdeer	U	+				
Mallard	U	+				
Black Duck	2	+				
*Sharp-tailed Grouse	U	U				
Marsh Hawk	U	U				
American Goldfinch	U	6				
Common Snipe	C	+				
Eastern Kingbird	8	+				
Red-winged Blackbird	7	2				
Savannah Sparrow	C	6				
Lincoln's Sparrow	C	12	+			
Swamp Sparrow	133	15			4	
Song Sparrow	21	35			53	+
Common Yellowthroat	87	19	15	2	39	+
Alder Flycatcher	2	6			4	
Rufous-sided Towhee	U	14			17	+
Chestnut-sided Warbler	U	5	U	2	U	1
Palm Warbler		6	5			
American Robin		4	U	+	11	3
Canada Warbler		53	U	6	6	50
Cedar Waxwing		8	4	6	3	1
Hermit Thrush		5	5	3	C	+
Slate-colored Junco		8	6	2	C	+
Nashville Warbler		19	4	13	28	14
Myrtle Warbler		3	5	12	U	7
White-throated Sparrow		14	7	15	60	21
*Northern Waterthrush		77	9	2	4	+
Ruby-crowned Kinglet		2	15	11	C	7
Magnolia Warbler		1	7	14	C	
Boreal Chickadee		1	U	4		
Swainson's Thrush		+	4	7	U	33
Chipping Sparrow		2	U	8	3	1
Winter Wren		5	U	3	1	11
Blackburnian Warbler		7	2	2	U	8
Black-and-white Warbler		+	2	4	2	10
Olive-sided Flycatcher		+	U	2	U	+
*Tennessee Warbler		U		12	U	37
*Blackpoll Warbler		37	U	U	U	U
Purple Finch		4	2	1	1	2
Yellow-bellied Flycatcher		3	U	2		24
Spruce Grouse		+	U	2		
*Gray Jay		+	2	2		
*Connecticut Warbler		U	U			
*Wilson's Warbler		+	+			
*Rusty Blackbird		2				
Golden-crowned Kinglet			8	6		9
Red-breasted Nuthatch			U	7	1	2
Cape May Warbler			U	16		
Blue Jay				5	3	3
Ovenbird			U	30	14	17
*Evening Grosbeak				U	U	U
Pine Siskin			U	2		
White-winged Crossbill			U	4		1
Brown Creeper				2	2	9
Veery				6	47	+
Northern Parula				U	U	23
*Bay-breasted Warbler				2		37
Ruffed Grouse					3	1
Rose-breasted Grosbeak					9	1
American Woodcock					3	+
Eastern Wood Pewee					+	4
Wood Thrush					+	2
Scarlet Tanager					+	2
Black-throated Green Warbler						26

[1] Bent 1937, Bent 1938, Bent 1939, Bent 1942, Bent 1953, Bent 1968, Bond 1959, Brewer 1967, Bridge and Bridge 1964, Brunton and Crins 1975, Chapman 1907, Erskine 1977, Hall 1961-1963, Kendeigh 1948, Linehan 1968; Loery 1966, 1969-1970; Martin 1960, Palmer 1949, Roberts 1932, Root 1942, Speirs and Orenstein 1975, Stewart and Aldrich 1952; Van Velzen 1972-1974, 1977.

[2] Number of censuses.

[3] Mean density per 40 hectares on plots where species was recorded. When density figures were not available, C = common, U = uncommon.

+ denotes presence on plot, but no established territory was determined.

* locally common

opening seemed a requirement for nest-site selection. In a study of four species of raptors (Broad-winged Hawk, Red-tailed Hawk, Barred Owl, and Great Horned Owl), Fuller (1979) found differential habitat use between individuals of the same species. White-cedar and tamarack swamps made up over 26% of the total home range and over 18% of the total detected locations of a female Barred Owl; another radioed female used tamarack in proportion to its availability. However, since lowland conifers made up a much smaller percentage of her home range (only 2%), use of upland types was significantly higher for this bird. He also reported changing habitat use and preference by individuals as home range shifted to new areas and different habitats occurred within the range. He attributed this shifting of habitat use to resource availability and potential competition with other species of raptors. Of the species studied, only the Red-tailed Hawk did not use lowland areas extensively. Although lowland conifer stands may not be preferred for nesting habitat, they may be important to this group of birds for other activities and at other times of the year. Forbes and Warner (1974) found a northern white-cedar swamp to be the preferred roosting habitat of a radioed Saw-whet Owl in central Minnesota. Tamarack swamps were most used by this species during winter in a study in Michigan (Mumford and Zusi 1958).

Winter populations of birds in lowland conifer stands vary with the seed crop. Black spruce trees bear seeds as early as ten years of age and become dependable producers, with heavy crops occurring about every four years (USDA Forest Service 1965). In addition, seeds are shed slowly and throughout the year. In good seed years or when seed crops are low elsewhere, an influx of northern finches (Pine Grosbeak, Pine Siskin, Red Crossbill, White-winged Crossbill) is not uncommon in black spruce stands. In contrast, nearly 98% of the tamarack seed crop in northeastern Minnesota was reported to fall before the end of October (Duncan 1954). Likewise, most of the seeds of northern white-cedar are dispersed by November (USDA Forest Service 1965). Even in heavy seed years, these species do not provide a good food source; birds present in winter in stands where tamarack or northern white-cedar are dominant are likely to be limited to permanent residents. The grouse, owls, woodpeckers, jays, chickadees, siskins, and crossbills do winter in northern forests.

FACTORS AFFECTING STAND COMPOSITION AND AVIAN COMMUNITIES

Fire

During periods of drought, the surface layers become dry enough to make bogs and swamps susceptible to fire. If the burn is light, the bog community will become reestablished when water levels return to normal (Curtis 1959). However, if the upper layers of peat are destroyed, an open bog-sedge meadow community may develop, with a mixture of leatherleaf and sedges growing in a loose sphagnum mat (Curtis 1959, Vogl 1964). This type of area may attract Savannah Sparrows which would not ordinarily be found in a bog with heavy shrub cover.

Although the lowland conifers are not resistant to fire, all reproduce well on burned organic soils if seed-bearing trees are nearby. Many of the extensive acreages of even-aged black spruce or white-cedar swamp and forest in the Lake States originated after fire (Curtis 1959). If the burned peat is dry enough however, paper birch (Betula papyrifera) and quaking aspen (Populus tremuloides) are likely to become established, making the successional pattern similar to that after fire on upland sites. These hardwoods, shrubs, and other competing vegetation will overtop many of the conifer seedlings and slow their growth, but, except on the best sites, the conifers will eventually become dominant. The results of a census conducted on the Seney National Wildlife Refuge[3] show the bird species present on an 8 hectare burned black spruce plot with many snags. Cape May and Magnolia Warblers, Ovenbirds, and Golden-crowned Kinglets, all present in a mature black spruce forest nearby, were not found in the burned stand.

Breeding Birds of a Burned Spruce Forest
Seney National Wildlife Refuge, 1978[3]

	# territorial males per 40 ha*
White-throated Sparrow	30
Chipping sparrow	25
Slate-colored Junco	15
American Robin	10
Myrtle Warbler	10
Nashville Warbler	7
Black-backed Three-toed Woodpecker	5
Winter Wren	5
Brown Creeper	2
Killdeer	+
Hairy Woodpecker	+
Lincoln's Sparrow	+

*actual counts expanded to be comparable with densities in Table 1.

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[3] Unpublished data, U.S. Fish & Wildlife Service.

Type Conversion and Peat Mining

During the late 1800's and early 1900's, many of the southernmost conifer swamps were drained for conversion to agricultural crops (Curtis 1959). Similar attempts were made farther north, but the harsher climate made agricultural ventures largely unsuccessful.

The extensive bogs and swamps of the Lake States are again receiving attention with the interest in the use of peat as an energy source. Peat has been mined on a small scale for years, mainly for horticultural purposes, with the northern Lake States accounting for over 40% of the total produced in the United States in 1977 (USDI Bureau of Mines 1978). Current research is focusing on the feasibility of mining peat on a much larger scale for conversion to a synthetic natural gas or for direct use as a fuel. If some of these peatlands are to be developed, guidelines for reclamation would have to be established and unique natural areas identified and preserved. Finland has been successfully using reclaimed peatlands for forestry purposes; production of forage and seed crops, cool season grasses and vegetables, or wild rice is also being considered on former peatland (Farnham 1978).

Mining and the resulting conversion to another vegetation type would undoubtedly have a great impact on birds. These activities would center in the peatlands where disturbance has been minimal in the past--those that do not produce merchantable timber, and, because of high water tables and unstable terrain, have received little recreational use.

Timber Management Practices

Though much of its acreage is classified as noncommercial, the lowland conifer type represents 13% of the total commercial forestland in the northern Lake States and nearly 5% of the commercial forestland in the New England states and New York (Kingsley 1976, Kingsley 1977, Peters and Bowers 1977, Spencer and Thorne 1972, Ferguson and Mayer 1970, Ferguson and Kingsley 1972). Black spruce and tamarack are cut as pulpwood where stands are large enough to make logging profitable, and white-cedar is harvested for use as posts, poles, and lumber products where its resistance to decay is of prime importance.

Harvesting and Site Preparation

Clearcutting is the recommended method for harvesting and reproducing the lowland conifers (Johnston 1977a,b; Heinselman 1959). Black spruce and tamarack reproduce best in full sunlight, and wind damage to these shallow-rooted species is minimized in the resulting even-aged stands. Northern white-cedar is highly preferred by white-tailed deer (Odocoileus virginianus) for winter shelter and browse, and timber management practices have in the last decade been influenced by their need for large, dense even-aged stands in traditional yarding areas (Verme 1965).

Cutting of cedar is generally done in strips or small blocks, leaving alternate rows of the same width for a seed source. Clearcut strips can vary in width from 1 chain (~20 meters) to 3 chains, depending on the height of trees in the adjacent uncut stands (Johnston 1977b). After the cutover areas are restocked (usually within 10 years), the uncut strips should be logged to prevent the new stands from becoming over-seeded and to reduce overbrowsing of the reproduction in the clearcuts by deer. Generally, shelterwood cuts are recommended at this point to ensure a seed source for the newly logged areas (Johnston 1975, 1977b). In most cases, however, this followup is not done, and the uncut strips remain. Black spruce and tamarack stands are cut either in strips or in large blocks, usually 40 acres (~16 hectares) or greater (Johnston 1977, Duncan 1952). If broadcast-burning of the cutover area is needed to improve the seedbed, to control disease, or to remove brush and undesirable residual stems, block cutting is more economical and preferred. However, since natural seeding cannot be relied on further than about 260 feet (~80 meters) from mature trees (Johnston 1975), direct seeding is usually required with this harvest method. Strip cutting is best applied in large stands that do not require broadcast-burning.

Clearcut-logging sets the vegetation of a stand back to an earlier successional stage. The avian communities will revert likewise, with bird species associated with open shrubby areas replacing those which nested in the mature forests (see Table 1). Unfortunately, the study of birds in lowland conifer communities has been confined almost entirely to natural stands; hence there is little documentation of avian use of logged areas. It does seem evident that species composition and densities will vary with the treatment after logging.

Black spruce, tamarack, and northern white-cedar reproduce best where slash cover is minimal. Burning is generally the recommended method for disposing of heavy slash, but, particularly in small cuts, full-tree skidding is less expensive and most often practiced (Johnston 1977a,b). Stands harvested by full-tree skidding or broadcast-burned following logging will not attract as many birds as cuts in which more slash is left. With little or no slash, Brewer's

Blackbirds and Common Yellowthroats are probably the most likely species to nest in a recently logged area. The bird species present on a lowland plot on Seney National Wildlife Refuge in Upper Michigan[4] censused by the spot-mapping method (Williams 1936) are shown below. Though actually altered by fire, the vegetation structure of this plot is very similar to that of a clearcut-logged area with heavy slash, with toppled trees and a few standing snags. In addition, Winter Wrens may be attracted to brush piles along the edge of a clearcut. Other species, though nesting elsewhere, will feed in snags and among the slash, or take advantage of the openings created by logging for hunting or flycatching.

Breeding Birds of a Burned Tamarack Forest
Seney National Wildlife Refuge, 1978[4]

Yellow-shafted Flicker
Tree Swallow
American Robin
Nashville Warbler
Common Yellowthroat
Brewer's Blackbird
White-throated Sparrow
Lincoln's Sparrow
Song Sparrow

Intermediate Treatment

On good sites, growth of deciduous brush (alder, dogwood, etc.) may severely suppress the conifer reproduction (Johnston 1977a,b). Aerial herbicide spraying is currently the most commonly used method of killing overtopping shrubs and hardwoods, despite the greater risk in lowland areas of contaminating open water. More research is being done (Johnston 1973) to determine if different broadcast-burning methods (season and severity) will sufficiently control shrub growth. Stands that are brushy will attract more species and have higher densities of birds than non-brushy stands or stands where shrub growth has been controlled. Sites allowed to revert to lowland brush may even attract species more common in upland deciduous clearcuts, such as the Chestnut-sided and Golden-winged Warblers.

In older stands of northern white-cedar, thinning improves both timber quality and deer habitat. Because the canopy closes gradually after thinning, stands must be rethinned periodically to maintain enough light for advance tree reproduction to continue growth (Johnston 1972). In these stands and in those which are understocked or have been direct-seeded, Ruby-crowned Kinglets, Magnolia Warblers, Myrtle Warblers, and Slate-colored Juncos will probably be common bird species. Blackburnian Warblers, Ovenbirds, Cape May Warblers, and Golden-crowned Kinglets are likely to be found breeding in the densest stands.

To ensure that northern white-cedar will remain dominant in the next stand, preparatory treatment, 5 to 10 years before harvesting, is recommended where intensive management for timber or deer habitat can be justified (Johnston 1977b). Hardwoods and undesirable trees are generally cut if they are merchantable, but girdling and application of herbicide are also used to kill these trees and control their vegetative reproduction. If cutting of these hardwoods creates an opening in the forest, shrub growth may increase and provide habitat for a bird species, such as the Nashville Warbler, not normally found nesting in the forest interior. Snags left by girdling or herbicide treatment may be used as avian nesting and feeding sites.

Rotation Age

Growth rates of lowland species vary tremendously with site. The best sites have moderately well decomposed woody peat and occur where the soil water is continuous with the ground water system and enriched by nutrients from areas with mineral soil (Johnston 1977a,b). The growth rates for tamarack and black spruce are poorest in open bogs, where site fertility is almost totally dependent on precipitation. White-cedar particularly requires actively moving soil water and, in lowland areas, it achieves its maximum growth rate along streams or drainage ditches (Johnston 1977b).

Though site, stocking, and the presence or risk of wind damage and disease may determine the actual harvest age, the recommended rotation for black spruce generally does not exceed 100 years, because butt rot becomes common thereafter on organic soils (Johnston 1977a). A rotation range of from 70 to 160 years has been established for white-cedar (Johnston 1977b), depending again on site and on the desired timber product. Stands managed to maximize board feet (110 years and older) provide optimum winter shelter for deer (Johnston 1977b) and also provide more years of available habitat for birds associated with mature forests. There is no information available on the minimum area of contiguous forestland required by these species. However, study being conducted in the Eastern deciduous forests (Whitcomb et al. 1979) indicates that certain bird species will no longer be present as forests are fragmented into small areas.

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[4] Unpublished data, U.S. Fish & Wildlife Service.

In general, treatment and succession following logging provide breeding habitat for the bird species that nest in natural lowland conifer stands. Species associated with relatively open bog areas with only scattered trees, such as the Palm Warbler, probably will not find cutover areas and the resulting stands suitable; their prime nesting habitat is generally in the extensive acreages of lowland conifers classified by foresters as noncommercial and little of this habitat is altered by logging activities. However, birds normally associated with shrubs, such as the Common Yellowthroat, Swamp Sparrow, and Song Sparrow, are wide-ranging and seem partial to the shrub vegetation form; hence they will find suitable growth in logged as well as undisturbed habitats. Populations of some species, such as the Nashville Warbler, may rise with the increase in the amount of edge between mature and young growth created by logging. Provided that large blocks of forest remain uncut, the recommended rotation age and the usual reliance on adjacent stands as the seed source for cutover areas ensures the presence of habitat required by bird species associated with mature conifers.

SUMMARY AND RECOMMENDATIONS

Since birds assist in controlling insect populations, and with the increased enthusiasm for recreational birding and the greater appreciation of nongame species as part of the ecosystem, the land manager should develop some guidelines for increasing bird habitat. With modifications in current logging practices, habitat for more species and greater densities of birds can be provided. Some recommendations for management follow.

1. Timber sales should be planned so as to maintain large blocks of mature forests. If strip cutting is to be used, the width of uncut strips should be increased, particularly if a followup cut is not anticipated.

2. As often as possible, rotation cycles should be lengthened to provide more years of available habitat for birds requiring mature forests.

3. A few snags and live trees should be left standing in a clearcut. Snags provide nesting and feeding sites for many bird species and are also good perches for raptors hunting in the openings created by logging.

4. Some slash should be left in a clearcut to increase bird use in the first growing season after logging.

5. If direct seeding is to be used to establish second growth, openings should be left where shrub growth would not need control.

6. Brush control should not be used unless the young conifers definitely need release. If herbicides are to be used, application late in the summer will reduce the chances of interference with nesting.

7. In the recommended thinning and preparatory treatment for northern white-cedar, undesirable trees should be girdled and not cut.

8. More information about avian use of lowland conifer habitats would be valuable. Research is especially needed on how bird communities change during the successional stages following logging.

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APPENDIX

Scientific Names of Bird Species

Ducks through Owls

Mallard	Anas platyrhynchos
Black Duck	Anas rubripes
Common Goldeneye	Bucephala clangula
Common Merganser	Mergus merganser
Red-breasted Merganser	Mergus serrator
Hooded Merganser	Lophodytes cucullatus
Sharp-shinned Hawk	Accipiter striatus
Marsh Hawk	Circus cyaneus
Red-tailed Hawk	Buteo jamaicensis
Broad-winged Hawk	Buteo platypterus
American Kestrel	Falco sparverius
Spruce Grouse	Canachites canadensis
Ruffed Grouse	Bonasa umbellus
Sharp-tailed Grouse	Pedioecetes phasianellus
American Bittern	Botaurus lentiginosus
Sora	Porzana carolina
Killdeer	Charadrius vociferous
American Woodcock	Philohela minor
Common Snipe	Capella gallinago
Great Horned Owl	Bubo virginianus
Long-eared Owl	Asio otus
Barred Owl	Strix varia
Great Gray Owl	Strix nebulosa
Saw-whet Owl	Aegolius acadicus

Woodpeckers

Yellow-shafted Flicker	Colaptes auratus
Pileated Woodpecker	Dryocopus pileatus
Yellow-bellied Sapsucker	Sphyrapicus varius
Hairy Woodpecker	Picoides villosus
Downy Woodpecker	Picoides pubescens
Black-backed Three-toed Woodpecker	Picoides arcticus
Northern Three-toed Woodpecker	Picoides tridactylus

Flycatchers and Swallows

Eastern Kingbird	Tyrannus tyrannus
Great Crested Flycatcher	Myiarchus crinitus
Yellow-bellied Flycatcher	Empidonax flaviventris
Alder Flycatcher	Empidonax alnorum
Eastern Wood Pewee	Contopus virens
Olive-sided Flycatcher	Nuttallornis borealis
Tree Swallow	Iridoprocne bicolor

Jays through Creepers

Blue Jay	Cyanocitta cristata
Gray Jay	Perisoreus canadensis
Black-capped Chickadee	Parus atricapillus
Boreal Chickadee	Parus hudsonicus
Red-breasted Nuthatch	Sitta canadensis
Brown Creeper	Certhia familiaris

Wrens through Starlings

House Wren	Troglodytes aedon
Winter Wren	Troglodytes troglodytes
American Robin	Turdus migratorius
Wood Thrush	Hylocichla mustelina
Hermit Thrush	Hylocichla guttata
Swainson's Thrush	Hylocichla ustulata
Veery	Hylocichla fuscescens
Golden-crowned Kinglet	Regulus satrapa
Ruby-crowned Kinglet	Regulus calendula
Cedar Waxwing	Bombycilla cedrorum
Starling	Sturnus vulgaris

Warblers

Black-and-white Warbler	Mniotilta varia
Golden-winged Warbler	Vermivora chrysoptera
Tennessee Warbler	Vermivora peregrina
Nashville Warbler	Vermivora ruficapilla
Northern Parula	Parula americana
Magnolia Warbler	Dendroica magnolia
Cape May Warbler	Dendroica tigrina
Myrtle Warbler	Dendroica coronata
Black-throated Green Warbler	Dendroica virens
Blackburnian Warbler	Dendroica fusca
Chestnut-sided Warbler	Dendroica pensylvanica
Bay-breasted Warbler	Dendroica castanea
Blackpoll Warbler	Dendroica striata
Palm Warbler	Dendroica palmarum
Ovenbird	Seiurus aurocapillus
Northern Waterthrush	Seiurus noveboracensis
Common Yellowthroat	Geothlypis trichas
Connecticut Warbler	Oporornis agilis
Wilson's Warbler	Wilsonia pusilla
Canada Warbler	Wilsonia canadensis

Blackbirds and Tanagers

Red-winged Blackbird	Agelaius phoeniceus
Rusty Blackbird	Euphagus carolinus
Brewer's Blackbird	Euphagus cyanocephalus
Scarlet Tanager	Piranga olivacea

Finches and Sparrows

Rose-breasted Grosbeak	Pheucticus ludovicianus
Evening Grosbeak	Hesperiphona vespertina
Purple Finch	Carpodacus purpureus
Pine Grosbeak	Pinicola enucleator
Pine Siskin	Spinus pinus
American Goldfinch	Spinus tristis
Red Crossbill	Loxia curvirostra
White-winged Crossbill	Loxia leucoptera
Rufous-sided Towhee	Pipilo erythrophthalmus
Savannah Sparrow	Passerculus sandwichensis
Slate-colored Junco	Junco hyemalis
Chipping Sparrow	Spizella passerina
White-throated Sparrow	Zonotrichia albicollis
Lincoln's Sparrow	Melospiza lincolnii
Swamp Sparrow	Melospiza georgiana
Song Sparrow	Melospiza melodia

THE ECOLOGY AND MANAGEMENT OF AVIAN COMMUNITIES IN MIXED HARDWOOD-CONIFEROUS FORESTS

Stanley A. Temple[1/], Michael J. Mossman[2/], and Bruce Ambuel[2/]

Abstract.--High horizontal diversity of vegetation in mixed hardwood-coniferous forests is identified as a key feature affecting avian communities. The extremely high bird species diversity of mixed forests is explained by patchiness of forest vegetation and selection of discrete habitat patches by birds that are typical of either more northerly or southerly forest types. Bird population densities, seasonality of avian communities, and impacts of succession on avian communities are interpreted in relation to forest ecology. Impacts of silviculture on avian communities are predicted, and modifications that favor diverse avian communities are suggested.

INTRODUCTION

In spite of their northerly distribution, the various types of mixed hardwood-coniferous forests in north central and northeastern United States support remarkedly rich avifaunas. The bird species diversities in these mixed forest types are among the highest of any of the forests in North America and the highest of any of the forest types in the north central and northeastern regions (Table 1). This conspicuously high bird species diversity provides the basis for our discussion of the bird communities of the mixed forests. We address ourselves to the following questions: What characteristics of the forest vegetation allow such diverse bird communities to develop? How do the geographic distributions and habitat preferences of bird species that occur in the mixed forests relate to the high species diversity? How are these diverse bird communities organized? What effects do modern forestry practices have on the diversity of bird communities in mixed forests? What types of management practices promote high bird species diversity in mixed forests?

DESCRIPTION OF MIXED HARDWOOD-CONIFEROUS FOREST VEGETATION

The following description of the hardwood-coniferous forests of the north central and northeastern U.S. begins by considering the presettlement forest biome. This historical approach seems worthwhile because much of the research on the dynamics of both forest and bird communities has been conducted using historical records or studying virgin relics and unmanaged forests. The same biological and physical processes illustrated in these studies continue to shape the composition of our modern, mixed forest biome, albeit altered by man's actions. A prerequisite to the management of this modern forest biome for non-game birds is an understanding of the complete range of forest environments in which the bird community evolved, and this comes only from an historical perspective.

Distribution and Composition of Forest Types

The mixed forest biome of the north-central and northeastern United States is roughly synonymous with the hemlock-white pine-northern hardwood region of Braun (1950). It covers the northern Great Lakes region, southern Quebec, Nova Scotia, New Brunswick and New England, dipping south along the Appalachian Mountains (Fig. 1). At the western boundary in northern Minnesota the biome grades into parkland and prairie; to the north, it is replaced by

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Table 1.--Comparisons of bird species diversity in various forest communities in the northeastern and north central United States[1]

Community Type[2]	Forest composition	Average No. of bird species per census route	Average species diversity index[3] per census route
Spruce-Hardwood	mixed	60.3	3.377
Adirondack Mountain	mixed	61.3	3.457
Northern Hardwoods	mixed	63.3	3.508
Wisconsin Driftless Area	deciduous	58.1	3.123
Eastern Lake Section	deciduous	54.4	2.938
St. Lawrence Valley	deciduous	55.9	3.063
Allegany Plateau	deciduous	54.9	3.135
Closed Boreal Forest	coniferous	51.5	3.262

[1] Data from an analysis of Breeding Bird Surveys (1968-1973) by Peterson (1975).

[2] See map in Peterson (1975).

[3] Calculations based on Shannon-Weaver function (Tramer 1969).

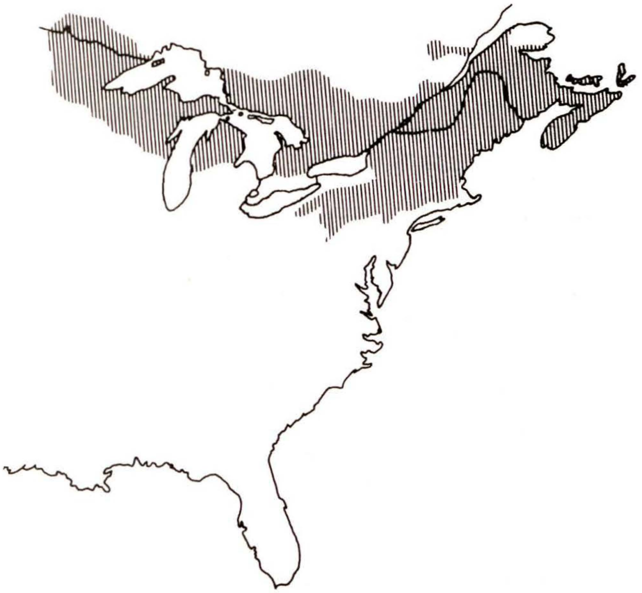

Figure 1.--The geographic distribution of mixed hardwood-coniferous forests in the north central and northeastern United States (adapted from Braun's (1950) map of the hemlock-white pine-northern hardwoods region). Forests within this region differ in their species composition, but all are mixed forests.

boreal forest and to the south by southern deciduous forest, savanna and mixed forest of the southern Appalachians. Various associations of hardwood-coniferous forest occur throughout this biome.

Curtis (1959) has given a most complete regional description of the presettlement hardwood-coniferous forest community. The major dominant tree species of the upland mixed forests of Wisconsin are, in order of increasing shade tolerance: jack pine, (*Pinus banksiana*); hill's oak, (*Quercus elipsoidales*); quaking aspen, (*Populus tremuloides*); red pine, (*P. resinosa*), white pine, (*P. strobus*); paper birch, (*Betula papyrifera*); red oak, (*Q. borealis*); red maple, (*Acer rubrum*); yellow birch, (*B. lutea*); basswood, (*Tilia americana*); hemlock (*Tsuga canadensis*); beech, (*Fagus grandifolia*); and sugar maple, (*A. saccharum*). Table 2 summarizes the composition and structure of typical stands of mixed forest in Wisconsin.

There are several geographic trends in the biome. In the extreme western portion of the biome, beech, hemlock and yellow birch successively disappear and white pine and basswood increase in importance. East of Wisconsin, red spruce (*Picea rubens*), sweet birch (*Betula lenta*) and gray birch (*B. populifolia*) join the forest and increase in importance along with hemlock and beech; jack pine, red pine and yellow birch decline. These compositional changes often involve the replacement of one species by an ecological equivalent with a similar life-form so that the physiognomy of the

Table 2.--Structure and composition of typical stands of hardwood-coniferous forest.[1]

Locality and Species	Plants per acre Less than 1" d.b.h.		Plants per acre More than 1" d.b.h.				
	Less than 1"tall	More than 1"tall	1-4"	4-10"	10-20"	20-30"	30+"
a. Wet-mesic swamp of cedar and fir in Vilas County, Wisconsin							
Abies balsamea	3800	1000	56	200	0	0	0
Acer rubrum	3000	200	39	9	4	0	0
Betula lutea	1600	0	0	0	7	0	0
B. papyrifera	0	0	3	44	14	0	0
Fraxinus nigra	400	400	0	19	0	0	0
Picea mariana	0	0	0	3	0	0	0
Populus tremuloides	0	0	0	0	4	0	0
Sorbus americana	1000	0	9	6	0	0	0
Thuja occidentalis	10,400	0	76	31	14	0	0
Quercus borealis	400	0	0	0	0	0	0
b. Mesic forest in Vilas County, Wisconsin							
Abies balsamea	40	15	23	1	0	0	0
Acer saccharum	20,160	5680	72	36	16	2	0
Betula lutea	7100	7	6	3	20	3	0
Ostrya virginiana	80	100	18	6	0	0	0
Picea glauca	0	0	0	0	0	1	0
Pinus strobus	0	0	0	0	2	2	1
Tilia americana	130	65	15	6	7	0	0
Tsuga canadensis	260	2	17	18	18	4	0
Ulmus americana	65	90	5	8	4	3	0
c. Mesic forest in Door County, Wisconsin							
Acer saccharum	17,280	960	11	17	41	0	0
Betula papyrifera	0	0	1	12	0	0	0
Fagus grandifolia	0	0	1	12	0	0	0
Fraxinus americana	2560	480	0	0	0	0	0
Ostrya virginiana	640	1440	3	0	0	0	0
Pinus strobus	0	0	0	0	2	1	1
Prunus serotina	160	0	0	1	0	0	0
Quercus borealis	160	0	0	0	2	0	0
Tsuga canadensis	0	0	6	0	4	1	0
d. Dry-mesic red pine forest in Oneida County, Wisconsin							
Acer rubrum	3400	1000	80	25	0	0	0
Betula papyrifera	0	0	35	31	2	0	0
Pinus resinosa	0	0	5	7	67	0	0
P. strobus	2800	1400	27	5	3	4	0
Populus grandidentata	0	0	3	5	1	0	0
P. tremuloides	0	0	1	3	1	0	0
Quercus borealis	400	0	23	24	1	0	0
e. Dry jack pine forest in Burnett County, Wisconsin							
Acer rubrum	312	62	14	6	2	0	0
Betula papyrifera	0	0	0	9	0	0	0
Pinus banksiana	0	144	71	59	33	0	0
P. strobus	164	20	0	0	2	0	0
Populus tremuloides	0	0	0	7	0	0	0
Quercus ellipsoidalis	1568	865	68	43	11	0	0

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[1] After Curtis (1959).

forest, which is so important to the bird community, changes less than a list of tree species might indicate.

Topography also varies from west to east as the gentle, glacial landscape of the lake states gives way to the montane landscape of Pennsylvania, New York and New England. In the lake states, variation in forest composition is often associated with changes in the underlying glacial deposits and in the depth of the water table which varies with slight changes in topography. The eastern region was also glaciated, but montane topography has a dominant influence upon the vegetation which varies with changes in altitude, exposure and bedrock(Braun 1950).

Within the mixed hardwood-coniferous forest, boreal elements such as black and white spruce (*Picea mariana* and *P. glauca*) increase toward the north while deciduous species such as the maples and oaks increase towards the south. In a sense, the biome may be considered a broad zone of transition or an ecotone between the boreal forest and southern deciduous forests; however, it is largely composed of unique tree and shrub communities which include important tree species that are essentially limited to the mixed forest biome (Braun 1950).

The composition of the upland, mixed forest on any particular site is determined by a complex interplay of edaphic factors, climate, succession, gap phase (sensu Watt 1947) disturbances (such as windthrows, disease and insect damage), and catastrophic disturbances (such as blowdowns, fire and insect or disease epidemics). The interaction of these biotic and physical factors constantly alters the forest environment, shifting the competitive advantage in a given locale from one tree species to another and creating a mosaic of forest types.

In the absence of disturbance, the replacement of shade intolerant trees by tolerant species and changes in the soil would theoretically result in a homogeneous climax forest over much of the hardwood-coniferous forest biome. Throughout much of the lake states region, sugar maple would become the single dominant tree. Largely because of disturbance, the mixed forest has never been dominated by one or a few shade tolerant species. Relatively small gaps in the canopy create favorable conditions for the growth of yellow birch, basswood, elms (*Ulmus americana; U. rubra*), white ash (*Fraxinus americana*), red maple and, if the gap is sufficiently large, white pine. Windthrown trees provide ideal seed beds for hemlock which is shade tolerant once established as a seedling. Catastrophic events often create conditions favorable for shade-intolerant pioneer species such as the pines, quaking aspen, paper birch and pin cherry (*Prunus pensylvanica*). However, catastrophic disturbances, when not associated with fire, and small scale disturbances of mesic forest do not necessarily lead to the establishment and growth of pioneer or gap phase species, but may be followed instead by the immediate reestablishment of mesic species from sprouts, and existing seedlings and saplings. This interplay of succession and disturbance tends to favor mixed forests over homogeneous forests of coniferous or hardwood species. Studies throughout the hardwood biome indicate that the dominant, presettlement forests were mixed hardwood-coniferous forests at various successional stages (Lutz 1930; Bromley 1935: Nichols 1935; Hough 1936; Graham 1941; Curtis 1959; Marsh 1965; Carroll 1973).

Successional Patterns in Mixed Hardwood-Coniferous Forests

Figure 2 outlines the basic pathways that succession follows, the effects of disturbances, and the relationship of mixed hardwood-coniferous forests to the other forest communities of the north central and northeastern regions. Table 2 shows the tree composition of typical stands of mixed forest. The structure and composition of stands is determined by a complex of environmental factors that results in variations in composition that follow major environmental gradients.

Rather than disrupting the mixed forest biome, fire, windthrow and other disturbances have contributed to a rich plant community by maintaining a dynamic balance between tree species (Graham 1941; Stearns 1949; Loucks 1970). In the presettlement hardwood-coniferous forests, this interplay of succession and disturbance created a complex mosaic of forest types in which all successional stages of forest were represented by stands of varying age and species composition (Watt 1947; Braun 1950; Bray 1956; Curtis 1959; Carroll 1973). This complex physiognomy has been an important factor in the evolution and persistence of the diverse community of birds in the biome. The diverse life-forms, vertical patterns of vegetation, and successional types present in the hardwood-coniferous forest provide a rich variety of habitats and resources for birds, allowing many species to coexist. Furthermore, localized changes in the composition of the forest vegetation through succession and disturbance continually alter the competitive environment for

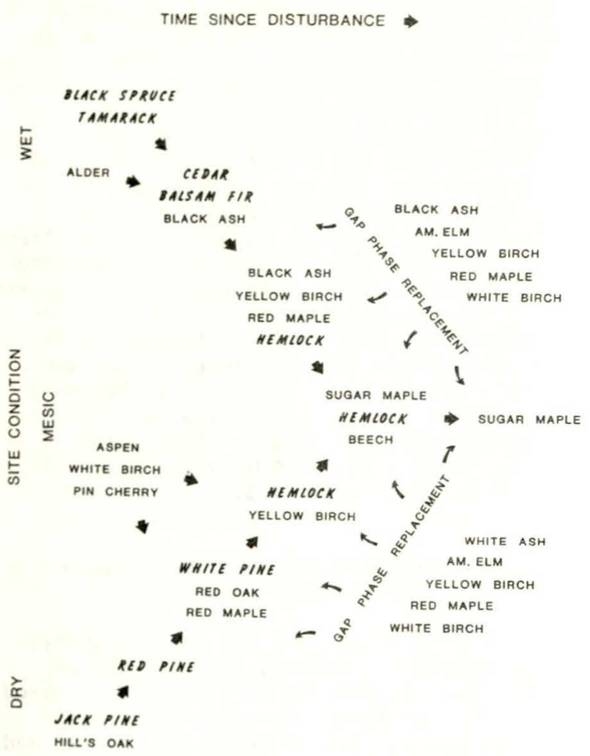
TIME SINCE DISTURBANCE
SITE CONDITION
WET
MESIC
DRY
BLACK SPRUCE
TAMARACK
ALDER
CEDAR
BALSAM FIR
BLACK ASH
GAP PHASE REPLACEMENT
BLACK ASH
AM. ELM
YELLOW BIRCH
RED MAPLE
WHITE BIRCH
BLACK ASH
YELLOW BIRCH
RED MAPLE
HEMLOCK
SUGAR MAPLE
HEMLOCK
BEECH
SUGAR MAPLE
ASPEN
WHITE BIRCH
PIN CHERRY
HEMLOCK
YELLOW BIRCH
GAP PHASE REPLACEMENT
WHITE ASH
AM. ELM
YELLOW BIRCH
RED MAPLE
WHITE BIRCH
WHITE PINE
RED OAK
RED MAPLE
RED PINE
JACK PINE
HILL'S OAK

Figure 2.-- A generalized scheme of forest succession in the mixed hardwood-coniferous forests of northern Wisconsin. Succession follows the arrows from left to right. Coniferous trees are italicized.

the resident birds species, preventing a single species or group of species from dominating the entire forest bird community.

Alterations of the Mixed Forests in Historical Times

Beginning with European settlement, historical changes have altered the species composition and physiognomy of the hardwood-coniferous forests. Some of these changes are permanent. Although local economic conditions, technology and the motivation of the early settlers and those who followed varied from New England to the Midwest, the various accounts of settlement reveal a common chronology of change throughout the biome.

Beginning with the arrival of the first settlers, selective cutting of the most economically valuable trees eliminated white pine from large tracts of mixed forest (Marsh 1965; Carroll 1973). In Wisconsin, pine was removed from forests where it grew at a density of only 3 or 4 trees per acre (Curtis, 1959). Following this high grading, the forest was clear-cut for timber and/or to clear the land for agriculture. Clear-cutting increased soil erosion, disrupted the water cycle and dried out the remaining forests (Marsh 1973; Curtis 1959). Fueled by slash, the incidence of forest fires and intense crown fires increased, further limiting the distribution and reproductive potential of those species sensitive to fire, such as hemlock and white pine (Curtis 1959).

Land in many areas proved uneconomical for farming and was abandoned (Curtis 1959; Marsh 1973). This land succeeded to second growth forest of shade intolerant trees or was reforested with selected species. In areas where agricultural land-use continued, the forest persisted as isolated woodlots in a rural landscape (Curtis 1956). Chestnut blight and dutch elm disease virtually eliminated the chestnut (*Castanea dentata*) and American elm from the biome, and increased populations of herbivores such as white-tailed deer and porcupine also had some impact, especially on hemlock, white cedar and white pine.

These historical changes reduced the amount of mixed hardwood-coniferous forest by eliminating hemlock and pine from many areas of deciduous forest; favored early successional species; and created a younger, less diverse, second-growth forest with a simple vertical profile.

Modern forestry practices are leading to managed succession throughout much of the biome. The two principle management strategies are even-aged management by clear-cutting or shelterwood and uneven-aged management by selective cutting. The former has most frequently been used to perpetuate shade intolerant species while the latter can only be used to manage shade tolerant species. The physiognomy of the forest which results from either management practice depends upon the length of rotation in even-aged management, the minimum merchantable size-class in uneven-aged management, and the area and configuration of timber stands. In the past, these management decisions have been made without regard to the bird communities of the biome. Whereas uneven-aged management and selective cutting could closely simulate gap phase disturbance, it is generally used to encourage the most valuable species and to eliminate poorly shaped individuals and uneconomical species (Curtis 1959). Clear-cutting and shelterwood management could also simulate disturbances such as blowdowns and fire, but have been used most frequently to favor single, homogeneous forest types on short rotations. The management practices continue the post-settlement pattern of: maintaining a forest of simple physiognomy by favoring conifer or hardwood forests over mixed forests; favoring early successional stages; and maintaining a young forest with a simple vertical profile.

The modern hardwood-coniferous forest is less complex and heterogeneous than the forest in which the birds of this biome evolved. In light of our current understanding of the effect that the spatial complexity of an environment has upon the distribution of birds species and the density and diversity of the bird communities, one would conclude that these differences have probably affected the bird community of the biome. The contrast between the presettlement and modern plant communities is a logical source of hypotheses related to the management of the biome for non-game birds.

SOURCES OF INFORMATION ON BIRD COMMUNITIES

The following discussion of bird communities of the mixed hardwood-coniferous forests is based on a combination of our own field work in the mixed forests of Wisconsin from 1976 to present and on the published accounts of other researchers. In Wisconsin, we have studied the bird communities of mixed forests primarily in two localities: the Apostle Islands in Lake Superior and the Baraboo Hills in central Wisconsin. The vegetation and general ecology of the Apostle Islands have been described by Beals and Cottam (1960) and the vegetation of the hardwood-coniferous forests in northern Wisconsin has been described by Brown and Curtis (1952). Lange (1976) describes the vegetation of the Baraboo Hills, a unique region slightly south of the normal range of mixed forests, which because of its topography supports typical hardwood-coniferous forest types. Less intensive field work has taken place in several other localities in northern Wisconsin, such as the Chequamegon National Forest and the Red Cliff Indian Reservation.

Within these study areas we have used a variety of techniques to study bird communities. We used the census procedures developed by Emlen (1971, 1977) to determine the species composition of the bird communities and the population densities of each species. We described the habitats occupied by breeding birds using the procedures described by James (1971) and James and Shugart (1970). In the Baraboo Hills we also used IPA mapping procedures (Ferry and Frochot 1970) to determine population densities.

BIRD COMMUNITIES OF HARDWOOD-CONIFEROUS FORESTS

Species Diversity

The high bird species diversity of the mixed hardwood-coniferous forests is one of the most important community characteristics that needs to be understood. Table 1 shows that the diversity of mixed forests exceeds the diversity of both the boreal coniferous forests, which are located to the north, and the deciduous forests to the south. There are two possible explanations for the biome's elevated species diversity. One possibility is that there are a large number of bird species restricted in geographic distribution to the mixed forests. Together these mixed-forest specialists might elevate the species diversity above that found to the north or south of the biome. Udvardy (1963) analyzed the distribution patterns of forest birds in North America. He found that mixed hardwood-coniferous forests contained only 5 species that had both the centers of their ranges and the majority of their ranges located in areas of mixed forest: the nashville warbler, black-throated blue warbler, blackburnian warbler, chestnut-sided warbler, and canada warbler. The overlap of these species' ranges with the distribution of mixed forests is not precise, and even within the mixed hardwood-coniferous forest biome, the specific habitat perferences of these species do not suggest that they are mixed forest specialists. Therefore, it does not seem likely that the high bird species diversity is the result of species being restricted to the mixed forests.

An alternative explanation is that there are a large number of bird species whose ranges lie primarily to the north or south of the mixed forests but overlap in the intervening areas. Thus, the bird communities of the hardwood-coniferous forests contain a mixture of bird species that are most typical of forest types to the north or south. In this respect, the avifauna of the mixed forests would be reacting to the mixed forests as an ecotone. It is well known that species diversity is often elevated in ecotones; this occurs apparently because species from each of the two adjoining biomes find suitable areas or patches of habitat, thus permitting coexistence within the ecotone and enriching its species diversity. Apparently this type of species enrichment occurs in the mixed forests; boreal forest and deciduous forest birds occur together in the mixed forests. Table 3 shows the north-south extent of the ranges of various mixed forest birds within Wisconsin, a state which has deciduous forests in its southern tier, mixed forests over the central regions, and coniferous forest in the far north. It is clear that the avifauna of these mixed forests is comprised of species that have extended their

Table 3.--Distributions of breeding forest birds of Wisconsin with respect to the distributions of deciduous, mixed hardwood-coniferous, and boreal coniferous forests[1]

(Extent of Species' Range)

S. Wisconsin ←→ N. Wisconsin

Breeding bird species	Deciduous forest	Mixed forest	Boreal forest
Sharp-shinned Hawk		XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXX
Cooper's Hawk	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXX
Goshawk		XXXXXXXXXX	XXXXXXXXX
Red-shouldered Hawk	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXX
Broad-winged Hawk	XXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXX
Spruce Grouse		XXXX	XXXXXXXXX
Ruffed Grouse	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXX
Mourning Dove	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXX
Yellow-billed Cuckoo	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXX
Black-billed Cuckoo	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXX
Long-eared owl		XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXX
Great Gray Owl		XXX	XXXXXXXXX
Barred Owl	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXX
Great Horned Owl	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXX
Ruby-throated Hummingbird	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXX
Red-headed woodpecker	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXX
Red-bellied Woodpecker	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXX	
Flicker	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXX
Pileated Woodpecker	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXX
Downy Woodpecker	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXX
Hairy Woodpecker	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXX
Yellow-bellied Sapsucker	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXX
Northern 3-toed Woodpecker		XXX	XXXXXXXXX
Black-backed Woodpecker		XXXXXXXXXXXXXX	XXXXXXXXX
Crested Flycatcher	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXX
Olive-sided Flycatcher		XXXXXXXXXXXXXXXXXX	XXXXXXXXX
Least Flycatcher	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXX
Alder Flycatcher	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXX
Acadian Flycatcher	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXX	
Yellow-bellied Flycatcher		XXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXX
Eastern Phoebe	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXX
Wood Pewee	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXX
Gray Jay		XXXXXXXXXX	XXXXXXXXX
Blue Jay	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXX
Crow	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXX
Raven		XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXX
Tufted Titmouse	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXX	
Black-capped Chickadee	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXX
Boreal Chickadee		XXXXXXXXXX	XXXXXXXXX
Brown Creeper		XXXXXXX	XXXXXXXXX
White-breasted Nuthatch	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXX
Red-breasted Nuthatch		XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXX
Bewick's Wren	XXXXXXXXXXXXXXXXXXXXXX		
House Wren	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXX
Winter Wren		XXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXX
Carolina Wren	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXX	
Brown Thrasher	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXX
Mockingbird	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXX	
Gray Catbird	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXX
American Robin	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXX
Eastern Bluebird	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXX
Olive-backed Thrush		XXXXXXXXXXXXXX	XXXXXXXXX
Gray-cheeked Thrush		XX	XXXXXXXXX
Wood Thrush	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXX
Hermit Thrush		XXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXX

Table 3.--Continued

Breeding bird species	(Extent of Species' Range) S. Wisconsin ← Deciduous forest	 Mixed forest	→ N. Wisconsin Boreal forest
Veery	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXX
Ruby-crowned Kinglet		XXXXXXXXXXX	XXXXXXXXXX
Golden-crowned Kinglet		XXXXXXXXXXXXXXXX	XXXXXXXXXX
Blue-gray Gnatcatcher	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXX	
Cedar Waxwing	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXX
Bell's Vireo	XXXXXXXXXXXXXXXXXXXXXXXX	XXXX	
Red-eyed Vireo	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXX
Warbling Vireo	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXX
Yellow-throated Vireo	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXX	
Solitary Vireo		XXXXXXXXXXXXXXXXXXXX	XXXXXXXXXX
Black-and-White Warbler	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXX
Prothonotary Warbler	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXX	
Golden-winged Warbler	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXX
Blue-winged Warbler	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXX	
Nashville Warbler	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXX
Parula Warbler		XXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXX
Yellow Warbler	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXX
Magnolia Warbler		XXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXX
Black-throated Blue Warbler		XXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXX
Yellow-rumped Warbler		XXXXXXXXXXXXXX	XXXXXXXXXX
Black-throated Green Warbler		XXXXXXXXXXXXXXXXXXXX	XXXXXXXXXX
Cerulean Warbler	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXX	
Blackburnian Warbler		XXXXXXXXXXXXXXXXXXXX	XXXXXXXXXX
Chestnut-sided Warbler	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXX
Pine Warbler	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXX	
Palm Warbler		XXXXXXXXXX	XXXXXXXXXX
Ovenbird	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXX
Northern Waterthrush	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXX
Louisiana Waterthrush	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXX	
Connecticut Warbler		XXXXXXXXXXXXXXXXXXXX	XXXXXXXXXX
Mourning Warbler	XXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXX
Common Yellowthroat	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXX
Yellow-breasted Chat	XXXXXXXXXXXXXXXXXXXXXXXX	XXXX	
Canada Warbler	XXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXX
American Redstart	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXX
Orchard Oriole	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXX	
Northern Oriole	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXX
Brown-headed Cowbird	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXX
Brewer's Blackbird	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXX
Common Grackle	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXX
Scarlet Tanager	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXX
Cardinal	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXX
Rose-breasted Grosbeak	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXX
Purple Finch		XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXX
Pine Siskin		XXX	XXXXXXXXXX
Red Crossbill		XXXXXXXXXXXXXXX	XXXXXXXXXX
White-winged Crossbill		XXXXXXXXXXXXXXX	XXXXXXXXXX
Rufous-sided Towhee	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXX
Dark-eyed Junco		XXXXXXXXXXXXXXXXXX	XXXXXXXXXX
White-throated Sparrow	XXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXX
Fox Sparrow		XXXX	XXXXXXXXXX
Song Sparrow	XXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXX

1/Distributions of forest types taken from Curtis (1959); distributions of birds taken from Gromme (1963).

ranges into mixed forest from the north or south.

The key to the maintenance of this high bird species diversity is the spatial complexity of the forest. Both the vertical and horizontal complexity of the vegetation are known to affect bird species diversity (MacArthur and MacArthur 1961), and it seems likely that horizontal complexity is relatively more important than vertical complexity in promoting diversity in the mixed forests. As we mentioned in our discussion of the physiognomy of the forest, one important characteristic of the forest is its patchiness. Hardwoods and conifers rarely form a truely homogeneous mixture. Rather, the dispersion of tree-types is contagious or clumped: both coniferous and deciduous trees tend to be found in discrete patches or groves. This dispersion pattern allows birds that are primarily adapted for coniferous vegetation to select patches of conifers in which to establish breeding territories, whereas those birds that are primarily adapted for living on deciduous vegetation can select patches containing predominantly deciduous trees in which to establish territories.

To demonstrate this selection by birds of patches of vegetation that are either more northerly or southernly in their affinities, we analyzed the vegetation within the territories of several warbler species breeding in the mixed forests of the Baraboo Hills of Wisconsin. Figure 3 shows the strong correlation between the northern affinity of the vegetation within a bird's territory and the percentage of that particular species range (on a north-south basis) that lies to the north of the site. Clearly, the bird species that have the most northerly geographic distributions are selecting for their territories those patches of forest that include the most northerly types of vegetation. The converse is true for southern bird species.

It seems that most birds of the mixed forests are not responding to the mixed forests as a single type of vegetation. Rather they are responding to the mixed forest as a mosaic of vegetation patches with either northerly or southerly affinities. This may be one of the most important ecological characteristics of the birds that breed in mixed forests, and as we shall mention later, it is perhaps the most important characteristic with relevance to forest management.

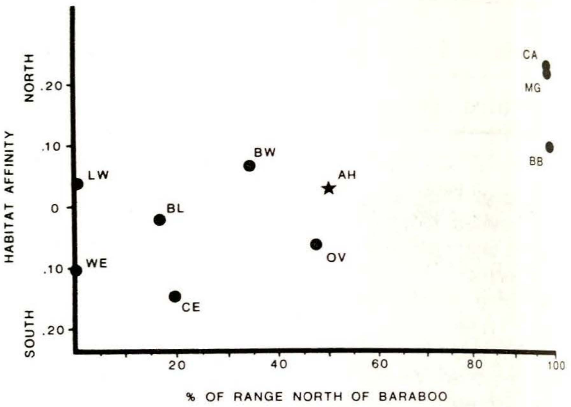

Figure 3.--The relationship between the geographic distribution of a species and the type of vegetation within its territory in the Baraboo Hills of central Wisconsin. The percent of range north of Baraboo was measured along the 90th meridean. Habitat affinity was calculated as N-S/N+S, where N is habitat similarity with Curtis' (1959) northern Wisconsin forest types and S is the similarity with southern Wisconsin forest types. Similarities were calculated as "coefficients of community" (Gleason 1920) using importance values for tree species. LW=Louisiana Waterthrush, WE=Worm-eating Warbler, BL=Blue-winged Warbler, CE=Cerulean Warbler, BW=Black-and-White Warbler, OV=Ovenbird, BB=Blackburnian Warbler, MG=Magnolia Warbler, CA=Canada Warbler, AH=available habitat.

Bird Population Densities In Hardwood-Coniferous Forests

Although mixed hardwood-coniferous forests are somewhat unique for their high bird species diversities, they are not very unusual in terms of the densities of birds that they support. From our own work and published accounts, we have assembled some representative breeding bird population densities for various types of mixed forest in the north central and northeastern U.S. (Table 4). These data suggest that most mixed-forest stands can be expected to support bird densities on the order of 150-300 territorial birds per 100 acres (40ha) during the breeding season. These figures are not very different from bird population densities reported for either boreal coniferous forests or northern hardwood forests.

Bird population densities are known to be affected by the productivity of the habitat that the birds are occupying. It seems reasonable, therefore, to expect that some, if not most, of the inter-stand variability in bird population densities in mixed forests can be accounted for by differences in productivity. In particular, for the majority of forest birds, which are primarily insectivorous

Table 4.--Population densities of breeding birds in various stands of mixed hardwood-coniferous forest in north central or northeastern United States.

	Sources of Data[1/]															
Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
A. Percent composition of vegetation in study area[2/]																
White cedar	+	0		0	0		+	0	0	0		0	0		0	
Hemlock		4		0	0		+	0	0	20	+	20	6	+	74	+
Pine		69		0	0		0	0	20	60	+	7	0		0	
Spruce-fir		0	+	73	90	++	34	53	0	0		0	0		0	
Total coniferous		73		73	90		41	53	20	80		27	6		74	
Maple-beech				0	1		+	24	20		++	20	56	++	23	
Yellow birch				0	9		+	23	7		+	10				
Aspen-white birch	+	22	+	27	0		0	0	5			0				
Total deciduous		27		27	10	+	59	47	80	20		73	94		26	
B. Bird population densities (pairs/40ha)[3/]																
Mourning dove	3	+	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Yellow-billed Cuckoo	0	0	0	0	0	0	0	0	0	0	0	+	0	+	0	0
Black-billed Cuckoo	0	0	0	0	0	0	0	0	0	0	1	0	0	+	0	0
Turkey Vulture	0	0	0	0	0	0	0	0	+	0	0	+	0	0	0	0
Goshawk	0	0	0	0	0	0	0	0	+	0	0	0	0	0	0	0
Coopers Hawk	0	0	0	0	0	0	0	0	+	0	+	0	0	0	0	0
Sharp-shinned Hawk	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Red-tailed Hawk	0	0	0	0	0	0	0	0	+	0	0	+	0	0	0	0
Red-shouldered Hawk	0	0	0	0	+	0	0	+	±	0	0	+	0	0	0	0
Broad-winged Hawk	0	0	0	0	0	0	0	0	0	0	+	0	0	0	0	1
Peregrine Falcon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Merlin	0	0	0	+	0	0	0	0	0	0	0	0	0	0	0	0
Ruffed Grouse	0	1	0	0	0	6	0	+	+	1	+	±	3	+	2	0
Great-horned Owl	0	0	0	0	0	0	0	0	0	+	0	0	+	0	±	0
Long-eared Owl	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Barred Owl	0	0	0	0	0	0	0	0	2	0	1	2	0	1	0	1
Saw-whet Owl	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Common Nighthawk	0	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Whip-poor-will	0	0	0	0	0	0	0	0	0	1	0	+	0	0	0	0
Chimney Swift	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ruby-throated Hummingbird	+	0	3	0	0	0	0	0	1	0	+	4	0	0	0	0
Common Flicker	3	2	0	+	0	0	0	0	3	0	0	+	0	+	0	2
Pileated Woodpecker	0	0	0	+	0	0	0	+	2	+	+	+	+	+	+	1
Red-bellied Woodpecker	0	0	0	0	0	0	0	0	4	0	0	+	0	1	0	0
Red-headed Woodpecker	0	0	0	0	0	0	0	0	1	0	0	±	0	0	0	0
Yellow-bellied Sapsucker	3	0	6	0	0	3	3	0	0	2	0	0	0	0	0	0
Hairy Woodpecker	3	1	0	0	+	+	1	3	2	3	1	4	2	4	3	3
Downy Woodpecker	1	+	0	0	0	0	0	0	6	2	0	2	0	5	0	2
Eastern Kingbird	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Great-crested Flycatcher	3	2	0	0	0	0	0	0	6	1	1	+	3	3	1	0
Eastern Phoebe	0	0	0	0	0	0	0	0	3	0	0	6	0	2	0	0
Yellow-bellied Flycatcher	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0
Acadian Flycatcher	0	0	0	0	0	0	0	0	8	0	0	36	0	5	0	0
Least Flycatcher	0	0	0	4	0	0	0	0	0	0	6	36	0	0	0	0
Eastern Pewee	3	16	0	0	0	0	6	0	14	6	14	16	1	10	0	0
Olive-sided Flycatcher	0	0	0	+	0	0	0	0	0	2	0	0	0	0	0	0
Tree Swallow	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bluejay	3	2	3	0	+	+	3	3	11	2	1	4	2	1	2	0

Table 4.--Continued.

	Sources of Data[1/]															
Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Gray Jay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+
Common Raven	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Common Crow	0	+	0	+	0	0	0	0	+	0	1	0	0	0	0	0
Black-Capped Chickadee	5	8	6	2	4	6	9	2	6	6	3	8	3	5	9	14
Carolina Chickadee	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0
Boreal Chickadee	0	0	0	5	0	0	+	0	0	0	0	0	0	0	0	0
Tufted Titmouse	0	0	0	0	0	0	0	0	0	0	0	+	0	9	0	0
White-breasted Nuthatch	0	0	0	0	0	0	0	0	6	1	2	6	2	5	5	0
Red-breasted Nuthatch	1	1	0	4	13	3	0	7	0	1	0	0	0	0	0	10
Brown Creeper	0	0	0	0	0	0	0	7	0	1	0	0	0	0	0	7
House Wren	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Winter Wren	13	0	0	4	0	0	0	3	1	1	1	0	0	0	0	5
Carolina Wren	0	0	0	0	0	0	0	0	0	0	0	0	0	+	0	0
Gray Catbird	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0
Brown Thrasher	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
American Robin	7	12	3	16	8	3	1	3	6	0	1	2	0	1	0	0
Wood Thrush	0	0	0	0	+	3	0	3	7	0	2	10	0	22	1	0
Hermit Thrush	0	8	6	+	8	0	1	3	0	10	0	0	5	0	6	5
Swainson's Thrush	0	0	0	21	4	1	14	13	0	0	0	0	0	0	0	3
Veery	0	+	9	0	+	18	0	7	8	5	8	6	4	0	5	0
Blue-gray Gnatcatcher	0	0	0	0	0	0	0	0	8	0	0	16	0	0	0	0
Golden-crowned Kinglet	0	0	7	0	33	0	0	32	0	0	1	0	0	0	0	2
Ruby-crowned Kinglet	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	+
Cedar Waxwing	0	4	0	0	0	0	0	0	1	0	1	+	0	0	0	0
Starling	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Solitary Vireo	3	0	0	2	17	0	3	26	0	4	0	0	0	0	1	2
White-eyed Vireo	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Yellow-throated Vireo	0	0	0	0	0	0	0	0	2	0	1	6	0	3	0	0
Red-eyed Vireo	3	1	17	14	0	20	54	10	14	10	32	36	25	14	1	17
Philadelphia Vireo	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Warbling Vireo	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Black & White Warbler	13	0	8	+	0	17	0	0	2	8	1	0	3	0	2	5
Worm-eating Warbler	0	0	0	0	0	0	0	0	1	0	0	+	0	0	0	0
Golden-winged Warbler	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blue-winged Warbler	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
Tennessee Warbler	0	0	0	+	0	0	0	0	0	0	0	0	0	0	0	0
Nashville Warbler	10	0	6	19	0	9	0	0	0	0	0	0	0	0	0	3
Northern Parula Warbler	7	0	0	4	+	0	26	3	0	0	0	0	0	0	0	5
Yellow Warbler	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Magnolia Warbler	0	0	17	32	42	31	10	45	0	4	0	8	2	0	25	9
Cape May Warbler	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0
Yellow-rumped Warbler	3	+	6	26	0	6	+	0	0	2	0	0	0	0	0	17
Black-throated Green Warbler	3	16	0	0	21	6	23	31	0	13	8	0	9	4	32	28
Black-throated Blue Warbler	5	0	0	0	21	3	29	16	0	6	2	0	6	0	9	0
Cerulean Warbler	0	0	0	0	0	0	0	0	+	0	0	4	0	3	0	0
Blackburnian Warbler	0	0	8	2	67	15	30	55	4	18	6	2	6	0	14	102
Chestnut-sided Warbler	0	0	+	0	0	14	+	0	0	0	0	0	0	0	0	0
Bay-breasted Warbler	0	0	0	95	0	0	0	0	0	0	0	0	0	0	0	1
Blackpoll Warbler	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pine Warbler	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Prairie Warbler	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Palm Warbler	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ovenbird	10	20	25	2	0	33	23	3	1	9	19	14	28	28	32	2
Northern Waterthrush	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0
Louisiana Waterthrush	0	0	0	0	0	0	0	0	8	0	0	6	0	4	0	0
Common Yellowthroat	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0

Table 4.--Continued.

Species	Sources of Data[1]															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Yellow-breasted Chat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mourning Warbler	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Connecticut Warbler	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hooded Warbler	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wilson's Warbler	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0
Canada Warbler	3	0	14	0	0	23	0	16	6	7	0	8	4	0	10	0
American Redstart	0	0	+	4	0	18	3	0	0	6	37	0	0	17	0	0
Common Grackle	0	0	+	0	0	0	0	0	+	0	0	0	0	0	0	0
Brown-headed Cowbird	+	+	0	0	0	0	0	0	9	0	+	16	0	2	0	0
Northern Oriole	2	0	0	0	0	0	0	0	5	0	0	+	0	0	0	0
Scarlet Tanager	10	0	0	0	4	3	3	7	15	3	3	20	3	9	5	0
Cardinal	0	0	0	0	0	0	0	0	3	0	0	8	0	5	0	0
Rose-breasted Grosbeak	+	0	0	0	8	+	0	3	17	0	0	18	0	3	0	0
Evening Grosbeak	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Indigo Bunting	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
Purple Finch	3	+	+	7	8	3	+	3	0	0	1	0	0	0	0	3
Pine Grosbeak	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0
Common Redpoll	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pine Siskin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
American Goldfinch	0	0	0	0	+	0	0	0	2	0	0	6	0	0	0	0
Red Crossbill	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
White-winged Crossbill	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vesper Sparrow	0	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rufous-sided Towhee	0	4	0	0	4	0	0	0	0	0	0	0	0	1	0	0
Dark-eyed Junco	3	4	+	9	33	0	0	21	0	10	0	0	0	0	0	13
Tree Sparrow	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chipping Sparrow	0	4	0	0	0	0	0	0	1	0	0	0	0	0	0	2
Field Sparrow	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
White-throated Sparrow	10	0	15	14	0	8	0	0	0	8	0	0	0	0	0	9
Song Sparrow	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	139	112	159	318	295	258	241	325	207	158	155	310	111	215	165	274

[1] Sources of Data: Kendeigh, 1948 (1, 2, 11); Kendeigh, 1946 (13, 15); Martin, 1960 (3, 6, 16); Stewart and Aldrich, 1952 (4); Stewart and Aldrich, 1949 (5, 8); Mossman, unpubl. (9, 12); Smith, 1944 (10); Williams, 1947 (14); Cope and Hensley; 1951 (7).

[2] Tree composition is recorded, when available, as percent of total number of trees. + indicates presence, ++ dominance and 0 absence.

[3] + indicates presence, 0 absence, and numbers density of males or pairs.

during the breeding season, the abundance of forest insects can be an important factor in determining local bird population densities. It is well known for example, that bird populations show dramatic numerical responses to localized outbreaks of forest insects that temporarily increase the productivity of a stand (Buckner and Turnock 1965). Conversely, stands with low productivity of forest insects can be expected to have reduced bird population densities.

Relative Abundance of Bird Species

The internal composition of the bird communities of mixed hardwood-coniferous forests can be analyzed in terms of the relative abundances of the various species that are members of the communtiy. In Table 4, we have presented for various types of mixed forests the population densities of each bird species present. Comparision of these figures reveals that there is definitely a consistent group of species which can be considered dominant in most mixed forests. These include: the ovenbird, red-eyed vireo, black-throated green warbler, blackburnian warbler, black-throated blue warbler, veery, and white-throated sparrow. Each species is present at densities that are conspicuously higher than those of other species, and together these species usually comprise 20-40 percent of the total number of individuals in the community.

If we rank sequentially the relative abundances of the 15 most abundant bird species in each of several types of mixed forests, a general pattern emerges (Figure 4). Basically, there are very few really common species, a relatively small number of moderately abundant species, and a large number of fairly uncommon species within the mixed hardwood-coniferous forests, a pattern which is common to many, if not most, forest bird communities.

Habitat Affinities of Mixed Forest Birds

Several researchers have attempted to describe the specific habitat preferences of birds in mixed forests (Kendeigh 1946, 1948; Martin, 1960; Stewart and Aldrich, 1949, 1952). Beals (1960) used an ordination technique to reveal the vegetation characteristics to which birds are responding. We have also used ordinations but have followed the technique described by James (1971) which is based on the vegetation surrounding the singing perches used by territorial males and presumably, is a reflection of the vegetation in the bird's territory. We have interpreted our ordination results in terms of several characteristics of the vegetation within bird territories that are relevent to questions of forest management. These include: relative abundance of pines, relative abundance of hemlocks, relative abundance of spruce-fir, relative abundance of sugar maple, relative abundance of aspen, average basal area of trees, density of trees, relative density of understory. In Table 5, we have summarized some of our ordination results in terms of these vegetation characteristics.

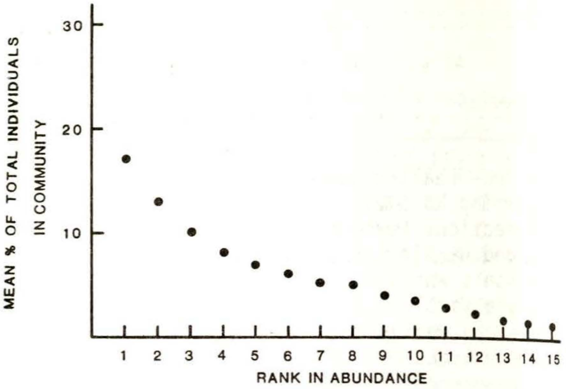

Figure 4.--The relative abundances of the fifteen most abundant bird species in various stands of mixed hardwood-coniferous forest. Data are taken from the same sources cited in Table 4.

Seasonality In Mixed Forest Bird Communities

So far we have restricted our discussion to the breeding bird communities of the mixed hardwood-coniferous forests. It is important to recognize, however, that the high bird species diversity and relatively high density of birds that characterize the mixed forests during the summer months do not prevail throughout the year. The contrast between the summer bird communities and the winter bird communities is striking. A comparison of the diversity and density of birds in two similar stands of mixed forests in northern Wisconsin, one in summer and the other in winter illustrates this. In June we detected an average of 39 species of birds per hour of censusing and an average density of 252 individuals per 100 acres (40 ha). In contrast, during our December censuses we detected an average of 5 species per hour of censusing and an average density of 16 individuals per 100 acres (40 ha).

From selected Christmas Bird Count records and our own experience, we can list the species of forest birds that regularly occur in the

Table 5.--An interpretation of habitat ordination results from breeding bird communities of mixed forests on the Apostle Islands, Wisconsin.

Alterations of vegetation within a stand	Bird species that are likely to become more abundant
1. Increasing abundance of pine	Sharp-shinned hawk, red-breasted nuthatch, hermit thrush, redstart, blackburnian warbler, Nashville warbler, pine warbler
2. Increasing abundance of hemlock	pileated woodpecker, yellow-bellied sapsucker, yellow-bellied flycatcher
3. Increasing abundance of spruce or fir	cedar waxwing, yellow-bellied flycatcher, swainson's thrush, redstart, parula warbler, blackburnian warbler
4. Increasing abundance of yellow birch and sugar maple	black-billed cuckoo, downy woodpecker, wood-pewee, least flycatcher, crow, brown creeper, veery, robin, warbling vireo, red-eyed vireo, Connecticut warbler, chestnut-sided warbler, black-throated green warbler, black and white warbler, Tennessee warbler, indigo bunting, rufous-sided towhee, rose-breasted grosbeak
5. Increasing abundance of aspen	yellow-shafted flicker, hairy woodpecker, house wren, veery, yellowthroat, mourning warbler, chestnut-sided warbler, song sparrow, white-throated sparrow
6. Increasing average basal area of trees	pileated woodpecker, solitary vireo
7. Increasing density of trees per unit area	scarlet tanager, ovenbird
8. Increasing density of understory	veery, black-throated blue warbler, Canada warbler

mixed forests of Wisconsin during winter; these include: goshawk, great horned owl, barred owl, ruffed grouse, downy woodpecker, hairy woodpecker, pileated woodpecker, blue-jay, gray jay, common raven, black-capped chickadee, red-breasted nuthatch, white-breasted nuthatch, brown creeper, evening grosbeak, cardinal, and purple finch. All these species are severely limited by the restricted supply of food available in the mixed forest during the winter. Many of the species, particularly the woodpeckers, chickadees, nuthatches, and creepers, are insectivorous and forage by probing in bark or dead wood. For these species, the presence in the forest of snags, dead limbs, and old mature trees is essential.

Successional Changes in Bird Communities

Although our main concern is with the bird communities of relatively mature stands of mixed hardwood-coniferous forests, it is important to summarize briefly the changes in the composition of the bird community as a stand progresses through successional stages of vegetation. Table 6 summarizes the bird communities associated with early, middle, and late seral stages leading to a beech-maple-hemlock forest in New York State. Bird species diversity increases progressively through these successional stages whereas bird densities tend to decrease slightly. In his analysis of Breeding Bird Surveys conducted by the U.S. Fish and Wildlife Service, Peterson (1975) found that in the ecological regions dominated by mixed hardwood-coniferous forests observers detected more species of birds in total than in any other ecological region of the U.S. Within the region characterized by "Spruce-hardwood forest" observers saw an average of 194.2 species per year for the period 1968-1973. The next highest species list was recorded in the "upper coastal plain" where an average of 169.8 species was observed each year. Although the mature mixed forests support a high species diversity, many of the birds

Table 6.--Bird species associated with seral stages leading to a mature beech-maple-hemlock forest on the Helderberg Plateau of central New York state (after Kendeigh 1946).

Bird Species	Seral Stage[1]			
	Early⟶	Middle⟶	Late⟶	Mature
Common Yellowthroat	+			
Song Sparrow	+			
Field Sparrow	+			
Chestnut-sided Warbler		+		
Rufous-sided Towhee		+		
Gray Catbird		+		
Alder Flycatcher		+		
Swamp Sparrow		+		
Red-winged Blackbird		+		
Indigo Bunting		+		
Brown Thrasher		+		
Yellow-breasted Chat		+		
Golden-winged Warbler		+		
American Robin			+	
American Redstart			+	
Nashville Warbler			+	
American Goldfinch			+	
Cedar Waxwing			+	
House Wren			+	
Woodcock			+	
Northern Oriole			+	
Common Flicker			+	
Eastern Kingbird			+	
Chipping Sparrow			+	
Ruby-throated Hummingbird			+	
Black-billed Cuckoo			+	
Purple Finch			+	
Mourning Dove			+	
Eastern Phoebe			+	
Eastern Bluebird			+	
Rose-breasted Grosbeak			+	
Downy Woodpecker			+	
Red-eyed Vireo			+	
Veery			+	+
Canada Warbler			+	+
Ovenbird			+	+
Magnolia Warbler			+	+
Black-and-White Warbler			+	+
Black-capped Chickadee			+	+
Black-throated Green Warbler			+	+
Blackburnian Warbler				+
Black-throated Blue Warbler				+
Hermit Thrush				+
White-breasted Nuthatch				+
Scarlet Tanager				+
Hairy Woodpecker				+
Ruffed Grouse				+
Wood Thrush				+
Solitary Vireo				+
Pileated Woodpecker				+
Crested Flycatcher				+
Great Horned Owl				+
Sharp-shinned Hawk				+
				+

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[1] Early=scattered briars, herbs, and low shrubs; middle=mature shrubs and small trees; late=scattered stands of tall trees and shrubs; mature=well-developed forest dominated by beech, maple, and hemlock.

that account for the extremely high total species list are birds of early successional stages. These early seral stages are, therefore, important in contributing to the overall bird species diversity in the regions dominated by mixed forests.

FOREST MANAGEMENT AND BIRD COMMUNITIES

We have already summarized briefly the impact that man has had on the mixed hardwood-coniferous forests of the north central and northeastern U.S. Our intent now is to outline in a general way the types of forestry practices that would promote what we feel is the single most significant ecological trait of the mixed forests bird communities: their high species diversity. First, we will list the important characteristics of the bird communities that relate to high species diversity:

(1) most forest birds respond to the mixed forest as a mosaic of patches which are either dominated by conifers or hardwoods. Few birds are actually selecting habitats that are a homogeneous blend of conifers and deciduous trees.
(2) most of the breeding birds are insectivorous and depend on a well-stratified forest with good vertical diversity in order to segregate their feeding niches.
(3) most breeding birds are insectivorous and depend on rich and varied insect populations in order to maintain high population densities.

(4) there are a few common or moderately common bird species that are dominant in the mixed forests, but the high species diversity is, in large part, the result of the many relatively uncommon species occurring in the mixed forests.
(5) from habitat ordinations, we can predict which bird species will be favored or adversely affected by specific habitat alterations.
(6) bird species diversity in mixed forests is high only during the summer; during the winter the species diversity is extremely low, and the species present have readily identifiable and fairly similar requirements of the mixed forest.
(7) maintaining a mosaic of seral stages promotes an overall diversity of birds within the regions that are dominated by mixed forests.

These ecological characteristics of the mixed forest bird communities must be reconciled with potential silviculture options in order to develop a set of management procedures that will sustain the entire complement of bird species in the biome and favor high bird species diversity.

Potential Silviculture Options For Mixed Forests

There are few specific management guidelines available for mixed forests because in almost all cases the silviculturalist is interested in either hardwoods or conifers, not a mixture of types. Tubbs (1977) provides a recent set of recommendations for the management of northern hardwoods and he includes brief descriptions of mixed stands in his discussion. Nonetheless, it seems most useful to discuss management options from the viewpoint of northern hardwood silviculture.

We will consider the following options for managing northern hardwoods: even-age management, uneven-age management and preservation. Although the effects that each of these management options would have on bird communities in mixed forests are as yet undemonstrated, we can make reasonable predictions on the basis of our knowledge of what these practices will do to the vegetation and our knowledge of what bird communities require. Although only a few specific studies of the impact of silviculture have been carried out, the recent results of Webb _et al_. (1977) should serve to emphasize the potential that silviculture has for altering bird communities.

Even-Aged Management

Even-aged management can be used to regenerate shade tolerant or intolerant species, and has the advantage over uneven-aged management of increased efficiency (Tubbs, 1977). Shelterwood and clear-cutting, the two methods of even-aged management most widely used, allow succession to proceed in some modified way with infrequent interventions into the forest for thinning or harvesting. Clear-cutting is generally used where the ultimate goal is reproduction of intolerant trees for pulpwood on a 50-70 year rotation, while the ultimate goal of shelterwood management is the reproduction of more valuable, shade tolerant hardwoods on a cycle of 100-120 years (Tubbs 1977).

We can identify some of the general effects that even-aged management has on mixed forest vegetation, and from these infer how bird communities are likely to respond. Shelterwood management encourages horizontal diversity of vegetation within a stand and will tend to favor a patchy distribution of tree species. This is particularly true if intermediate cuts favor moderately intolerant, as well as tolerant species, and a patchy distribution of conifers and hardwoods. Clear-cutting for pulpwood generally favors monotypic stands with a low horizontal diversity of vegetation, and the prescribed rotations of 50-70 years do not allow much diversity to develop due to natural disturbances. Both methods of even-aged management reduce the vertical diversity of vegetation within a stand by favoring single age-classes of trees, reducing the diversity of tree species, and opening the canopy. The opening of the canopy, in turn, tends to increase the development of the understory. Traditionally, the intermediate cuts reduce the density of dead and diseased trees.

In terms of the important ecological characteristics of the mixed forest bird communities, we can say that even-aged management has the following benefits and disadvantages for promoting high bird speices diversity.

(1) by promoting horizontal diversity in the forest vegetation shelterwood management can enhance bird species diversity, particularly if intermediate cuts can be made in such a way as to encourage a patchy distributuion of tree species.

(2) by reducing vertical diversity in the forest vegetation, even-aged management will tend to reduce the foraging opportunities available to birds and, hence, will reduce both the diversity and density of birds within specific patches of vegetation.

(3) by reducing the density of dead or diseased trees within a stand, even-aged management can reduce the productivity of insects in the forest and the availability of nesting cavities. This has a particularly important impact on the winter bird community which includes mostly bird species which probe in bark or wood to extract insects.

(4) from our understanding of the habitat requirements of individual bird species, we can predict some of the specific effect of even-aged management. Clear-cutting will create early seral stages and favor the bird species that prefer this type of habitat. Even-aged management will probably favor the more common members of the bird community, but may eliminate some of the less common species that contribute to high diversity.

Within the accepted guidelines for even-aged management of mixed forests there are several possibilities for minor modifications that would be beneficial to the mixed forest bird communities. We offer these as suggestions, but it should be realized that these are mostly unproven techniques:

(1) after clear-cutting or a shelterwood cut, an area is usually allowed to regenerate naturally through successional stages. The planting of small (3 ha) patches of conifers, particularly hemlocks and red or white pines, within the stand soon after cutting sould insure that conifer patches will develop. This would increase the horizontal diversity of vegetation in the stand, and would also increase vertical diversity of vegetation since conifers have a different vertical profile than hardwoods.

(2) when intermediate cuts are made to improve the quality of harvestable trees, several other objectives could simultaneously be achieved. These include allowing patches of conifers to persist within the hardwoods, preserving all snags or diseased trees that are not directly threatening valuable species, and creating snags by girdling species that are to be eliminated anyway and leaving them standing.

(3) within the constraints of silvicultural practices and economics, rotations should be as long as possible in clear-cut management, and cutting cycles should be as long as possible in shelterwood management.

Uneven-Aged Management

Uneven-aged management results in a different set of modifications of the mixed forest vegetation. Although current trends lean towards even-aged management, most of the management that has taken place in the past in mixed forests has been uneven-aged silviculture (Tubbs. 1977).

Under an uneven-aged management program, individual trees within the stand are selected for harvest or culling on the basis of species, age, diameter, and form. Maximum tree size in a stand depends upon whether management is for pole lumber or saw logs. The periodic removal of highly desirable trees from the forest results in several changes in forest vegetation that can have an impact upon bird communities. Uneven-aged management favors shade tolerant species which can reproduce under the canopy. The development of shade tolerant seedlings and saplings along with the growth of shrubs in canopy openings created by selective cuts, creates a forest which is vertically diverse. This vertical diversity is enhanced where the maximum tree size is large, and is reduced where it is small. The elimination of intolerant trees reduces the horizontal diversity of the forest. As in uneven-aged management, diseased, poorly formed and uneconomical trees are culled. Conifers cannot be maintained in a stand by uneven-aged management.

We can make some predictions about the impact that uneven-aged management would have on bird communities in the mixed hardwood-coniferous forests, but again there has been almost no research that would clearly prove these predictions valid. The following, however, seem to be the likely outcomes:

(1) by enhancing vertical diversity in the forest vegetation, uneven-aged management will favor high densities of a few species of birds.
(2) by reducing horizontal diversity, uneven-aged management will tend to depress the overall species diversity within the stand.
(3) by reducing the density of snags and overmature trees, uneven-aged management reduces the availability of insects for certain birds, particularly those that overwinter in the forest.
(4) by maintaining the forest in a seral stage close to the climax, uneven-aged management reduces the overall bird species diversity of a region by eliminating the early seral-stage habitats that some birds require. However, this may provide habitat for bird species of the forest interior which may not find suitable habitat in younger stands.
(5) when compared with even-aged management, uneven-aged management results in more frequent disturbance of the forest for harvesting, but the disturbance is not as severe as in even-aged management. Various bird species may respond in different ways to the frequency and severity of disturbance.

We can again offer some unproven suggestions for modifying current uneven-age management procedures in such a way that bird communities will benefit; these include:

(1) increasing horizontal diversity within a stand by either planting small patches (about 3ha) of conifers or allowing patches of conifers to develop and persist.
(2) simulating gap phase replacement by periodically opening up small patches and allowing them to pass through normal succession
(3) allowing snags to persist, as was suggested under even-aged management.
(4) cutting trees only of the largest size class that is economically feasible, thus maximizing vertical diversity of the stand.

Preservation

Preservation as a management practice is less well defined than the two options previously discussed. It may range from a completely "hands-off" policy, to active management for maximum esthetic and recreational benefits. For this discussion we take preservation to mean minimal intervention with management for esthetics, scientific research and/or wilderness recreation. If enough land were managed by preservation (i.e., thousands of hectares), this would result in mixed forest vegetation similar to the presettlement forests in which succession and disturbance created a mosaic of vegetation types with high horizontal and vertical diversity. On smaller management units the results of preservaiton will be less predictable. Small areas are likely to be maintained as a single seral stage by succession or catastrophic disturbances, such as ice and wind storms or fire.

Management by preservation has the following benefits and disadvantages for promoting high bird species diversity:

(1) tracts of land which are sufficiently large can offer horizontal and vertical diversity of vegetation that supports a diverse avian community.
(2) smaller areas of land will have a more uniform vegetation type which may be suddenly changed by catastrophic disturbances. Their contribution to an area's bird diversity will depend entirely upon whether they supply a unique habitat.

Recommendations for managing these areas for birds follow directly from these and include:

(1) large tracts of wildlands should be managed so as to allow natural succession and disturbance to occur and, thus, create diverse habitats for birds.
(2) if managing for the diversity of bird species is the principle goal, it is inappropriate to manage small areas of mixed forest by preservation. If small tracts of land are not to be economically exploited, they would best be managed for a forest type which is unavailable in the area.

Our management recommendations are specifically aimed at increasing the vertical and horizontal diversity of forests which are managed for lumber, pulpwood and other uses, thereby simulating the mosaic pattern of vegetation characteristic of the primeval forest. As we currently understand the dynamics of bird communities, this strategy will help sustain the full complement of the bird species of the hardwood-coniferous forest and maintain the region's high species diveristy.

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APPENDIX I

Common and scientific names of bird species mentioned in the text

Turkey Vulture (*Cathartes aura*)
Goshawk (*Accipiter gentilis*)
Cooper's Hawk (*A. cooperii*)
Sharp-shinned Hawk (*A. striatus*)
Red-tailed Hawk (*Buteo jamaicensis*)
Red-shouldered Hawk (*B. lineatus*)
Broad-winged Hawk (*B. platypterus*)
Peregrine Falcon (*Falco peregrinus*)
Merlin (*F. columbarius*)
Spruce Grouse (*Canachites canadensis*)
Ruffed Grouse (*Bonasa umbellus*)
American Woodcock (*Philohela minor*)
Mourning Dove (*Zenaida macroura*)
Yellow-billed Cuckoo (*Coccyzus americanus*)
Black-billed Cuckoo (*C. erythropthalmus*)
Great Horned Owl (*Bubo virginianus*)
Long-eared Owl (*Asio otus*)
Barred Owl (*Strix varia*)
Saw-whet Owl (*Aegolius acadicus*)
Common Nighthawk (*Chordeiles minor*)
Whip-poor-will (*Caprimulgus vociferus*)
Chimney Swift (*Chaetura pelagica*)
Ruby-throated Hummingbird (*Archilochus colubris*)
Belted Kingfisher (*Megaceryle alcyon*)
Common Flicker (*Colaptes auratus*)
Pileated Woodpecker (*Dryocopus pileatus*)
Red-bellied Woodpecker (*Melanerpes carolinus*)
Red-headed Woodpecker (*M. erythrocephalus*)
Yellow-bellied Sapsucker (*Sphyrapicus varius*)
Hairy Woodpecker (*P. pubescens*)
Downy Woodpecker (*P. villosus*)
Black-backed 3-toed Woodpecker (*P. arcticus*)
Northern 3-toed Woodpecker (*P. tridactylus*)
Eastern Kingbird (*Tyrannus tyrannus*)
Great Crested Flycatcher (*Myiarchus crinitus*)
Eastern Phoebe (*Sayornis phoebe*)
Acadian Flycatcher (*Empidonax virescens*)
Yellow-bellied Flycatcher (*E. flaviventris*)
Alder Flycatcher (*E. traillii*)
Least Flycatcher (*E. minimus*)
Eastern Pewee (*Contopus virens*)
Olive-sided Flycatcher (*Nuttalornis borealis*)
Tree Swallow (*Iridoprocne bicolor*)
Blue Jay (*Cyanocitta cristata*)
Gray Jay (*Perisoreus canadensis*)
Common Raven (*Corvus corax*)
Common Crow (*C. brachyrhynchus*)
Black-capped Chickadee (*Parus atricapillus*)
Carolina Chickadee (*P. carolinensis*)
Boreal Chickadee (*P. hudsonicus*)
Tufted Titmouse (*P. bicolor*)
White-breasted Nuthatch (*Sitta carolinensis*)
Red-breasted Nuthatch (*S. canadensis*)
Brown Creeper (*Certhia familiaris*)
House Wren (*Troglodytes aedon*)
Winter Wren (*T. troglodytes*)
Bewick's Wren (*Thryomanes bewickii*)
Carolina Wren (*Thryothorus ludovicianus*)
Mockingbird (*Mimus polyglottus*)
Gray Catbird (*Dumetella carolinensis*)
Brown Thrasher (*Toxostoma rufum*)
American Robin (*Turdus migratorius*)
Wood Thrush (*Hylocichla mustelina*)
Hermit Thrush (*Catharus guttata*)
Swainson's Thrush (*C. ustulata*)
Gray-cheeked Thrush (*C. minima*)
Veery (*C. fuscescens*)
Eastern Bluebird (*Sialia sialis*)
Blue-gray Gnatcatcher (*Polioptila caerulea*)
Golden -crowned Kinglet (*Regulus satrapa*)
Ruby-crowned Kinglet (*R. calendula*)
Cedar Waxwing (*Bombycilla cedorum*)
Starling (*Sturnus vulgaris*)
Solitary Vireo (*Vireo solitarius*)
White-eyed Vireo (*V. griseus*)
Bell's Vireo (*V. belii*)
Yellow-throated Vireo (*V. flavifrons*)
Red-eyed Vireo (*V. olivaceus*)
Philadelphia Vireo (*V. philadelphicus*)
Warbling Vireo (*V. gilrus*)
Black-and-white Warbler (*Mniotilta varia*)
Prothonotary Warbler (*Protonotaria citrea*)
Worm-eating Warbler (*Helmitheros vermivorus*)
Golden-winged Warbler (*Vermivora chrysoptera*)
Blue-winged Warbler (*V. pinus*)
Tennessee Warbler (*V. peregrina*)
Nashville Warbler (*V. ruficapilla*)
Northern Parula Warbler (*Parula americana*)
Yellow Warbler (*Dendroica petechia*)
Magnolia Warbler (*D. magnolia*)
Cape May Warbler (*D. tigrina*)
Yellow-rumped Warbler (*D. coronata*)
Black-throated Green Warbler (*D. virens*)
Black-throated Blue Warbler (*D. caerulescens*)
Cerulean Warbler (*D. cerulea*)
Blackburnian Warbler (*D. fusca*)
Chestnut-sided Warbler (*D. pensylvanica*)
Bay-breasted Warbler (*D. castanea*)
Blackpoll Warbler (*D. striata*)
Pine Warbler (*D. pinus*)
Prairie Warbler (*D. discolor*)
Palm Warbler (*D. palmorum*)
Ovenbird (*Seiurus aurocapillus*)
Northern Waterthrush (*S. noveboracensis*)
Louisiana Waterthrush (*S. motacilla*)
Common Yellowthroat (*Geothlypis trichas*)
Yellow-breasted Chat (*Icteria virens*)
Mourning Warbler (*Oporornis philadelphia*)
Connecticut Warbler (*O. agilis*)
Hooded Warbler (*Wilsonia citina*)
Wilson's Warbler (*Wilsonia pusilla*)
Canada Warbler (*W. canadensis*)
American Redstart (*Setophaga ruticilla*)
Red-winged Blackbird (*Agelaius phoeniceus*)
Brewer's Blackbird (*Euphagus cyanocephalus*)
Common Grackle (*Quiscalus quiscala*)
Brown-headed Cowbird (*Molothrus ater*)
Orchard Oriole (*Icterus spurius*)
Northern Oriole (*I. galbula*)
Scarlet Tanager (*Piranga olivacea*)
Northern Cardinal (*Cardinalis cardinalis*)
Rose-breasted Grosbeak (*Pheuticus ludovicianus*)
Evening Grosbeak (*Hesperiphona vespertina*)
Indigo Bunting (*Passerina cyanea*)
Purple Finch (*Carpodacus purpureus*)

APPENDIX I (continued)

Pine Grosbeak (*Pinicola enucleator*)
Common Redpoll (*Carduelis flammea*)
Pine Siskin (*C. pinus*)
American Goldfinch (*C. tristis*)
Red Crossbill (*Loxia curvirostra*)
White-winged Crossbill (*L. leucoptera*)
Vesper Sparrow (*Pooecetes gramineus*)
Rufous-sided Towhee (*Pipilo erythropthalmus*)
Dark-eyed Junco (*Junco hyemalis*)
Tree Sparrow (*Spizella arborea*)
Chipping Sparrow (*S. passerina*)
Field Sparrow (*S. pusilla*)
White-throated Sparrow (*Zonotrichia albicollis*)
Fox Sparrow (*Passerella iliaca*)
Swamp Sparrow (*Melospiza georgiana*)
Song Sparrow (*M. melodia*)

AVIAN COMMUNITIES: APPROACHES TO DESCRIBING THEIR HABITAT ASSOCIATIONS

Gerald J. Niemi

Lee Pfannmuller[1/]

Abstract.--Four approaches are presented which enable wildlife managers to consider many avian species simultaneously in management objectives. The northeastern Minnesota avifauna is used to test each approach. Three approaches included the classification of avian species into structural successional stages, life forms, or their sociological associations. The fourth approach, habitat niche, depicts species response to quantitative habitat variables. The background, methods, data analysis, interpretation, and advantages/disadvantages of each approach are discussed.

INTRODUCTION

Wildlife managers are faced with the difficult task of predicting the impacts of habitat alterations on wildlife species. Historically, their predictions have been based on empirical data or broadly defined "animal communities." During the last ten to fifteen years, however, the ease of assimilating and integrating large quantities of data by computer has broadened the range of techniques available for modeling natural systems. Our objective is to define and describe four management approaches that are currently available to managers for modeling bird populations. We will briefly discuss the background, methods, data analysis, interpretation, and major advantages and disadvantages of each approach. Hopefully, these discussions will provide recommendations for guiding the future direction of non-game bird management.

The four approaches considered in the following pages are:

Successional Stages - a simplistic approach that identifies the bird species associated with forest types along successional gradients.

Life Form Associations - a multi-level approach that identifies assemblages of species with similar reproductive and feeding strategies.

Species Associations - a multivariate approach that identifies species with similar distributions across a range of defined communities.

Habitat Niche Analysis - a multivariate approach that assumes species occupy a mathematically definable habit hyperspace.

Each approach was utilized in an attempt to model songbird populations from northeastern Minnesota. The successional stage and life form models were examined with data from published reports, our own unpublished data, and empirical data. The species association model was modified from the work of Pfannmuller (1979), while the habitat niche model was modified from the work of Niemi (1977).

Natural Setting

The glacially-influenced landforms of northeastern Minnesota (Wright and Watts 1969; Olcott and Siegal 1978) support a rich mosaic of upland and lowland forests (Ohmann and Ream 1971; Grigal and Ohmann 1975; Dean 1971). Throughout the region glacially deposited features such as end moraines, drumlin fields and glacial lake beds dominate the terrain. This topographical diversity is reflected by similar diversity among vegetation cover types. Located in an ecotone between the northern boreal forests and the eastern deciduous forests of North America, the transitional plant communities of northeastern Minnesota have been described by several plant ecologists since Cooper's (1913) original work on Isle Royale.

The original vegetation of northeastern Minnesota consisted of a complex mosaic of red pine (Pinus resinosa), jack pine (Pinus banksiana), and white pine (Pinus strobus) forests,

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black spruce (*Picea mariana*) and tamarack (*Larix laricina*) bogs, and forests of pioneer hardwoods. The latter consisted primarily of quaking aspen (*Populus tremuloides*) and paper birch (*Betula papyrifera*) and, in the more mature stands, balsam fir (*Abies balsamea*). Maintained primarily by lightning-induced fires and insect epidemics, these early communities were dominated by disturbance-adapted species (Heinselman 1973; Ahlgren 1975; Grigal and Ohmann 1975). Because disturbance was a frequent natural occurrence prior to man's intervention, a true 'stable climax' may rarely have developed (Heinselman 1973).

Today, logging activities generally replace natural disturbance as the method of stand renewal. Although the glacially-scoured and fire-controlled terrain of northeastern Minnesota was originally quite heterogeneous, man's activities have added to the disturbed and patchy nature of the forest.

The vegetational diversity that is characteristic of this region is an important influence upon the size and diversity of avian populations. The limited number of density estimates that have been reported for breeding populations in the area (Green et al. 1978) are considerably higher than values reported from similar cover types in Canada (Erskine 1977). Minnesota estimates range from approximately 500 pairs/km^2 in recent clearcuts and stunted conifer bogs to 1000-1500 pairs/km^2 in wetland shrub stands. Even the highest breeding densities reported in Canada rarely exceeded 500-600 pairs/km^2. Several factors may be responsible for this discrepancy. First, the method for determining the number of territorial males per plot was more conservative in the studies by Erskine (1977). Second, many study plots in Minnesota were small; ranging from 2 to 5 ha in size, while study plots in Canada were a minimum of 16 ha in size. The influence of plot size upon population estimates has been noted by Oelke (1966). The difference in plot size, however, reflects an important difference between the forests of Canada and Minnesota. Large, continuous stands of homogeneous cover types, common in Canada, are rare in the disturbed forests of northeastern Minnesota.

Minnesota's northeastern forests are also characterized by a rich diversity of breeding species. Unlike the rest of the state where members of the blackbird family (*Icteridae*) dominate the avifauna, wood warblers (*Parulidae*) contribute the largest percentage of both individuals and species to the summer avifauna of northeastern Minnesota (Fig. 1). Other important passerine families include the sparrows, grosbeaks and finches (*Fringillidae*) with approximately 15 breeding species, the tyrant flycatchers (*Tyrannidae*) with approximately 8 breeding species, and the thrushes (*Turdidae*) with approximately 5 breeding species (Green and Janssen 1975). Several species found in our northeastern forests are typically classified as boreal species and are quite rare in the continental United States. These include the black-backed three-toed woodpecker, spruce grouse, goshawk and boreal owl (Green and Janssen 1975). The habitat requirements of these species may deserve the special attention of wildlife managers in areas with a boreal element.

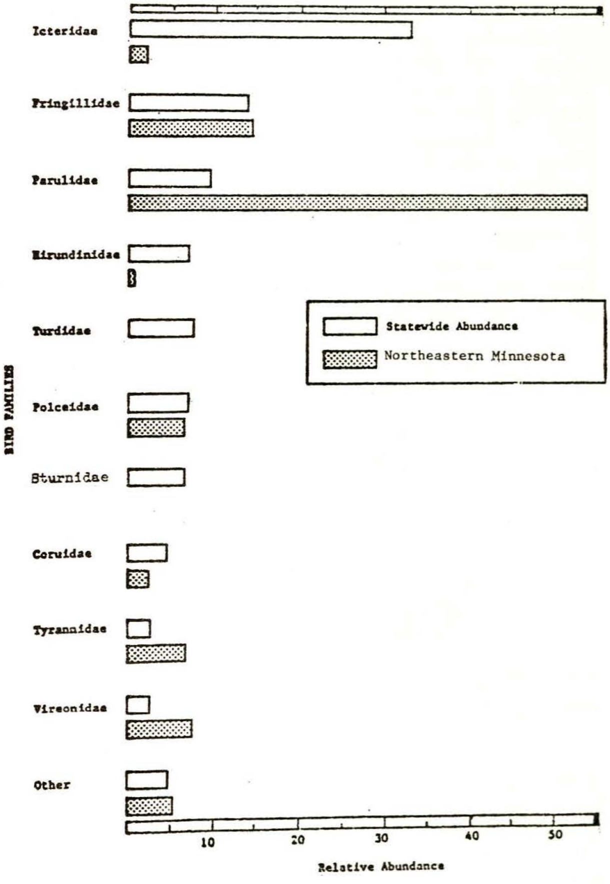


Figure 1.--The relative abundance of major passerine bird families in the State of Minnesota compared with northeastern Minnesota.

Data for this paper were drawn largely from two major studies conducted in northeastern Minnesota. One was conducted in an area of extensive taconite development located east of the mining towns of Hoyt Lakes and Babbitt, Minnesota (Pfannmuller 1979). The second study was conducted in an area within and surrounding the 1971 Little Sioux burn, located approximately 20 miles northwest of Ely, Minnesota and near the Island Lake Reservoir, approximately 20 miles north of Duluth, Minnesota (Niemi 1977). Other studies from which data were drawn include Todd and Doran (1976), Green et al. (1978), Bergstedt and Neimi (1974), and Green (1971a).

Bird Species and Data Base

Because more than 250 species of birds are known to occur in northeastern Minnesota, we felt it was practical to limit the number of species considered in this paper. We defined our data base by including only terrestrial species that are summer residents. Terrestrial species were arbitrarily defined as species found in communities ranging from the cattail-sedge marshes (where standing vegetation is present all year) to the drier upland forests. Thus, we excluded species found in the emergent aquatic marshes (where vegetation is present throughout much of the year) and open water areas. Species were further excluded if they could be classified into one of the following four categories:

1. Man-adapted species found commonly near settlements, towns, and cities;
2. Species with specific habitat or niche requirements;
3. Species in which we lack sufficient data; and/or
4. Species in northeastern Minnesota that are on the limit of their breeding range.

The species data base and the classification criteria are shown in table 1.

The concept of excluding species may seem contradictory to multiple species management. However, limiting the number of species in management models is appropriate if the limitations are based on sound rationale. For example, should species found in association with man's settlements be managed in forest ecosystems? Many of these species are much more abundant today than they were in pre-settlement times (Graber and Graber 1963). Species with specific habitat requirements may require special management strategies, especially if those requirements are limited in their availability. Species for which we are lacking data are particularly important. These species should be given research priority in order to determine their habitat requirements and to determine if their population levels are stable or declining. Finally, managing species on the limits of their range may not benefit the species and their inclusion could negatively influence species indigenous to an area.

One of the primary reasons for defining a species base was to focus attention on species that were particularly dependent on vegetational communities in northeastern Minnesota. Since the data base was established after both the habitat niche and species association analyses were completed, some species that were excluded from the data base, may be included in subsequent tables and figures.

SUCCESSIONAL STAGE APPROACH

Background

The general concept that birds select habitats based on the vegetation structure or habitat physiognomy has been expressed by several researchers (e.g., Lack 1933; Odum 1950; Svardson 1949; Hinden 1965; James 1971). Since succession has been described as an orderly process involving changes in the "structure" of habitats (Odum 1959), it seems natural to classify bird species into communities that are based on the structural categories found along successional gradients. In light of the relationship between bird species and successional stages, it is surprising to note that there are few systematic inventories of the birds inhabiting various stages. Erskine (1977), after discussing the birds of various forest types, comments as follows, "the need for systematic data on birds of successional and edge habitats could hardly be made more obvious." Nevertheless, some pertinent data are available in Kendeigh (1945), Johnston and Odum (1956), Martin (1960), Haapanen (1965), Shugart and James (1973), Holt (1974), and Erskine (1977).

Method

We defined a series of 11 forest types which are the predominant cover types found in northeastern Minnesota. They are described as follows:

> Grassland-forbaceous - An open upland area that lacks trees and shrubs. The flora is composed of grasses (Gramineae spp.) and a wide assortment of "weeds" standing up to 1 m high. The cover type is limited and occurs only in early clearcuts, intensely burned areas, or settlements.

Table1 .--Bird species data base for northeastern Minnesota. Species list includes those considered to be summer residents excluding waterbirds such as loons, grebes, ducks, coot, gulls, and terns as adapted from the annotated list in Green et al. (1978).

SPECIES	CLASSIFICATION CRITERIA 1/				
	INCLUDED IN ANALYSIS	URBAN ADAPTED	SPECIAL NEEDS	LACK OF DATA	RANGE LIMIT
Double-crested Cormorant			X		
Great Blue Heron			X		
American Bittern	X				
Turkey Vulture				X	
Goshawk				X	
Cooper's Hawk				X	X
Sharp-shinned Hawk				X	
Red-tailed Hawk	X				
Broad-winged Hawk	X				
Bald Eagle			X		
Marsh Hawk	X				
Osprey			X		
Merlin				X	
American Kestrel	X				
Spruce Grouse	X				
Ruffed Grouse	X				
Sandhill Crane				X	
Virginia Rail					X
Sora	X				
Killdeer		X			
American Woodcock	X				
Common Snipe	X				
Upland Plover					X
Spotted Sandpiper			X		
Mourning Dove		X			X
Black-billed Cuckoo					X
Great Horned Owl				X	
Barred Owl				X	
Long-eared Owl				X	
Short-eared Owl				X	
Common Nighthawk		X			
Chimney Swift		X			
Ruby-throated Hummingbird			X		
Belted Kingfisher			X		
Common Flicker	X				
Pileated Woodpecker	X				
Red-headed Woodpecker					X
Yellow-bellied Sapsucker	X				
Hairy Woodpecker	X				
Saw-whet Owl				X	
Whip-poor-will					X
Downy Woodpecker	X				
Black-backed 3-toed Wood				X	
Eastern Kingbird	X				
Great-crested Flycatcher					X
Eastern Phoebe			X		
Yellow-bellied Flycatcher	X				
Alder Flycatcher	X				
Least Flycatcher	X				
Eastern Wood Pewee	X				
Olive-sided Flycatcher	X				
Tree Swallow	X				
Bank Swallow			X		
Rough-winged Swallow			X		

Table 1.--Continued

SPECIES	INCLUDED	URBAN ADAPTED	SPECIAL NEEDS	LACK OF DATA	RANGE LIMIT
Barn Swallow		X	X		
Cliff Swallow		X	X		
Purple Martin		X			
Gray Jay	X				
Blue Jay		X			
Common Raven			X	X	
Common Crow		X			
Black-capped Chickadee	X				
Boreal Chickadee	X				
White-breasted Nuthatch					X
Red-breasted Nuthatch	X				
Brown Creeper			X	X	
House Wren		X			
Winter Wren				X	
Short-billed Marsh Wren	X				
Catbird	X				
Brown Thrasher	X				
Robin		X			
Wood Thrush					X
Hermit Thrush	X				
Swainson's Thrush	X				
Veery	X				
Eastern Bluebird			X		
Golden-crowned Kinglet	X				
Ruby-crowned Kinglet	X				
Cedar Waxwing		X			
Starling		X			
Solitary Vireo	X				
Red-eyed Vireo	X				
Philadelphia Vireo				X	
Warbling Vireo		X			
Black & White Warbler	X				
Golden-winged Warbler					X
Tennessee Warbler				X	
Nashville Warbler	X				
Parula Warbler	X				
Yellow Warbler		X			
Magnolia Warbler	X				
Cape May Warbler	X				
Yellow-rumped Warbler	X				
Blk-throated Green Warbler	X				
Blackburnian Warbler	X				
Chestnut-sided Warbler	X				
Bay-breasted Warbler	X				
Pine Warbler				X	
Palm Warbler				X	
Ovenbird	X				
Northern Waterthrush			X		
Connecticut Warbler	X				
Mourning Warbler	X				
Yellowthroat	X				
Wilson's Warbler				X	
Canada Warbler	X				
American Redstart	X				
House Sparrow		X			
Bobolink		X			
Eastern Meadowlark		X			

Table 1.--Continued

SPECIES	INCLUDED	URBAN ADAPTED	SPECIAL NEEDS	LACK OF DATA	RANGE LIMIT
Western Meadowlark		X			
Yellow-headed Blackbird					X
Redwinged Blackbird		X			
Baltimore Oriole		X			X
Rusty Blackbird				X	X
Brewers Blackbird		X			
Common Grackle		X			
Brown-headed Cowbird		X			
Scarlet Tanager	X				
Rose-breasted Grosbeak	X				
Evening Grosbeak	X				
Purple Finch	X				
Pine Siskin				X	
American Goldfinch	X				
Red Crossbill				X	
White-winged Crossbill				X	
Savannah Sparrow		X			
Vesper Sparrow		X			
Dark-eyed Junco	X				
Chipping Sparrow	X				
Clay-colored Sparrow					X
White-throated Sparrow	X				
Lincoln's Sparrow	X				
Swamp Sparrow	X				
Song Sparrow		X			

TOTAL SPECIES

1/ See text for explanation.

Cattail-sedge marsh - An open, wet area that lacks trees and shrubs. The flora is composed primarily of cattails (*Typhaceae*) and sedges (*Cyperaceae*) standing up to 2 m high. The cover type has a limited distribution in northeastern Minnesota.

Heath muskeg bog - An open lowland area that lacks trees; shrubs are rarely present. The flora is composed primarily of heath species (*Ericaceae*) standing up to 1 m high. The cover type is common in northeastern Minnesota.

Young open shrub - An upland shrub with scattered dead and/or live trees. Structurally, the habitat consists of a dense shrub layer, up to 3 m high, and a well-developed herbaceous layer. The flora may be composed of deciduous saplings such as quaking aspen, paper birch, or shrub species such as hazel (*Corylus cornuta*) or juneberry (*Amelanchier spp*.). The cover type is very common and is present within 3 to 12 years following logging or forest fire.

Wetland shrub - A lowland shrub area with scattered live and/or dead trees. Structurally the habitat consists of a dense shrub layer, approximately 3 m high and a variable herbaceous layer. The dominant floral species are alder (*Alnus rugosa*) and willow (*Salix spp*.). The cover type is quite common.

Young deciduous - An upland, medium-aged, tree stand with variable shrub and herbaceous layers. Structurally, the vegetation consists of a dense, deciduous tree layer, ranging from 3 to 9 m high. The typical tree species are quaking aspen and paper birch. The cover type is common 12 to 30 years following forest fire or logging.

Young coniferous - An upland, medium-aged, tree stand with sparse shrub and herbaceous layers. Structurally the vegetation consists of a dense coniferous tree layer, ranging from 3 to 9 m high. The typical tree species may be jack pine, red pine, white pine, white spruce (Picea glauca) or balsam fir. The cover type is common 12 to 30 years following forest fire or logging.

Semi-open conifer lowland - A stand whose structure is intermediate between that of the heath muskeg bog and the mature lowland conifer bog. Structurally the vegetation consists of a dense, low-lying heath layer, up to 1 m high, and a low to moderately dense tree layer up to 6 m high. The tree species are usually black spruce or tamarack. The cover type is fairly common.

Mature deciduous upland - A closed-canopy, deciduous upland stand with a moderate to dense tree layer, ranging from 9 to 20 m high, and a variable shrub and herbaceous layer. The tree species are usually quaking aspen or paper birch, although northern hardwoods (e.g., maple and basswood) may predominate near Lake Superior. The cover type is very common.

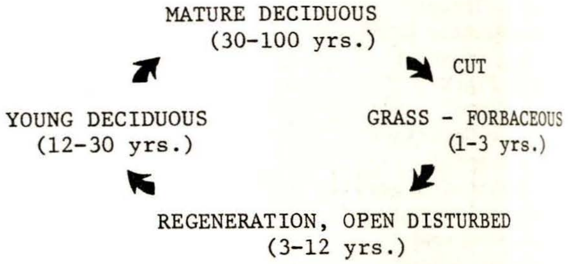
Mature coniferous upland - A closed-canopy, coniferous upland stand with a moderate to dense tree layer, ranging from 9 to 20 m high, and a sparse shrub and herbaceous layer. The tree species may include red pine, jack pine, white pine, white spruce, or balsam fir. The cover type is common and is often an actively-managed community.

Mature conifer lowland - A closed-canopy, coniferous lowland stand with a moderate to dense tree layer, up to 20 m high, a sparse shrub layer, and a dense herbaceous layer (comprised of moss and heath species). The tree species are usually black spruce or tamarack or occasionally white cedar (Thula occidentalis). The cover type is very common.

Bird species were then classified into one or more of these 11 cover types, depending on their use of each habitat for either reproduction and/or feeding. Data were extracted from a variety of sources including Pfannmuller (1979), Green and Niemi (1977), Todd and Doran (1976), Bergstedt and Niemi (1974), Green (1971a), field experience, or consultation with local experts.

Data Analysis and Interpretation

The results of the classification are shown in Table 2. The table provides a framework for modeling the habitat distributions of bird species in northeastern Minnesota. Using these data, the manager can predict some of the impacts of habitat alteration. For example, the following successional sequence would result if a mature deciduous forest were cut:



The rotation of species through this deciduous sere could be approximated from the information in Table 2.

As shown in Table 2, there is a general pattern of increasing number of species from the grass-forb type to the mature deciduous upland. Since the grass-forb and cattail-sedge types are the least complex (essentially one-layered) and the mature deciduous upland is the most complex (multi-layered), this increase generally reflects the complexity of the vegetation. The young open shrub and wetland shrub types are intermediate in structural complexity and the number of species generally associated with these types are also intermediate. However, if the number of dead or live trees is substantial in these types, then the numbers of bird species and individuals can also be quite high.

Advantages

1. The approach provides a baseline to build more sophisticated and realistic models for predicting the impacts of forest management.

2. The successional types are easily interpreted by most users.

3. The model permits the manager to make broad generalizations regarding the impact of forest management on non-game birds.

Table 2.--Life form association, successional stages used for reproduction (X), feeding (O), and adaptability index for the bird species data base defined in Table 1.

SPECIES	Life form 1/	Grass-Forb	Cattail-Sedge	Muskeg Bog	Young Open Shrub 2/	Young Deciduous	Young Coniferous	Mature (upland) Deciduous	Mature Coniferous Upland	Semi-Open Conifer Lowland	Mature Conifer Lowland	Wetland Shrub	ADAPTABILITY 3/ Total X	Total 0	Index
American Bittern	3		X 0	X 0									2	2	3
Red-tailed Hawk	9	0			X 0			X					2	2	3
Broad-winged Hawk	11	0			0			X 0					1	3	2.5
Marsh Hawk	5	0	X 0	X 0	0								2	4	4
American Kestrel	14	0			X 0								1	2	2
Spruce Grouse	10			X					X 0	X	X 0		4	2	5
Ruffed Grouse	5				X 0	X 0		X 0					3	3	4.5
Sora	3		X 0									X 0	2	2	3
American Woodcock	3,5	X	0		X	X	X					X 0	5	2	6
Common Snipe	3	X	X 0	X 0								X 0	4	3	5.5
Common Flicker	13	0			X 0			X					2	2	3
Pileated Woodpecker	13							X 0					1	1	1.5
Yellow-bellied Sapsucker	13							X 0	X 0				2	2	3
Hairy Woodpecker					X 0			X 0					2	2	3
Downy Woodpecker	13				X 0	X 0		X 0				0	3	3	4.5
Eastern Kingbird	8,11	X 0			X 0							X 0	3	3	4.5
Yellow-bellied Flycatcher	6								X 0	X 0	X 0		3	3	4.5
Alder Flycatcher	8				X 0							X 0	2	2	3
Least Flycatcher	8,11					X 0		X 0	X 0				3	3	4.5
Eastern Wood Pewee	8,11							X 0	X 0				2	3	3
Olive-sided Flycatcher	8,11				X 0					X 0		X 0	3	3	4.5
Tree Swallow	14	X 0		X 0	X 0					X 0			4	4	6
Gray Jay	10								X 0	X 0	X 0		3	3	4.5
Black-capped Chickadee	14					X 0	X 0	X 0					3	3	4.5
Boreal Chickadee	14								X 0	X 0	X 0		3	3	4.5
Red-breasted Nuthatch	14							X 0	X 0		X 0		3	3	4.5
Short-billed Marsh Wren	3,6,8	X 0	X 0	X 0									3	3	4.5
Catbird	5,6,7,8				X 0							X 0	2	2	3
Brown Thrasher	5,6,7,8				X 0							X 0	2	2	3
Hermit Thrush	5					X 0	X 0	X 0	X 0	X 0	X 0		6	6	9
Swainson's Thrush	7,8								X 0	X 0	X 0		3	3	4.5
Veery	5,6				X 0	X 0		X 0					3	3	4.5
Ruby-crowned Kinglet	10							X 0		X 0			2	2	3
Golden-crowned Kinglet	10							X 0		X 0			2	2	3
Solitary Vireo	8,11						X 0	X 0		X 0			3	3	4.5
Red-eyed Vireo					X 0	X 0		X 0					3	3	4.5
Black and White Warbler	6				X 0	X 0		X 0	X 0	X 0		X 0	6	6	9

Table 2.--continued

SPECIES	Life Form	Grass-Forb	Cattail-Sedge	Muskeg Bog	Young Open Shrub	Young Deciduous	Young Coniferous	Mature Deciduous Upland	Mature Coniferous Upland	Semi-open Coniferous Lowland	Mature Conifer Lowland	Wetland Shrub	ADAPTABILITY Total X	ADAPTABILITY Total 0	ADAPTABILITY Index
Nashville Warbler	6						X 0	X 0[4]	X 0	X 0	X 0		5	5	7.5
Parula Warbler	11							X 0[4]	X 0		X 0		3	3	4.5
Magnolia Warbler	8,10,11						X 0	X 0[4]			X 0		3	3	4.5
Cape May Warbler	10									X 0	X 0		2	2	3
Yellow-rumped Warbler	10						X 0	X 0[4]	X 0	X 0	X 0		5	5	7.5
Black-throated Green Warbler	8,10,11							X 0[4]					1	1	1.5
Blackburnian Warbler	10								X 0		X 0		1	1	1.5
Chestnut-sided Warbler	8				X 0	X 0	X 0	X 0				X 0	5	5	7.5
Bay-breasted Warbler	10,11									X 0	X 0		2	2	3
Ovenbird	5					X 0	X 0	X 0	X 0				4	4	6
Connecticut Warbler	6								X 0	X 0	X 0		3	3	4.5
Mourning Warbler	6,8				X 0	X 0	X 0						3	3	4.5
Yellowthroat	3,6,8		X 0	X 0						X 0		X 0	4	4	6
Canada Warbler	6,8					X 0		X 0	X 0				3	3	4.5
American Redstart	8,9,11					X 0		X 0				X 0	3	3	4.5
American Goldfinch	5,6,7,8	X 0			X 0							X 0	3	3	4.5
Purple Finch	10,11								X 0				1	1	1.5
Scarlet Tanager	9,11							X 0					1	1	1.5
Evening Grosbeak	10,11				X 0		X 0		X 0		X 0		4	4	6
Rose-breasted Grosbeak	8,9,11					X 0		X 0					2	2	3
Dark-eyed Junco	5						X 0		X 0	X 0	X 0		4	4	6
Chipping Sparrow	7,8,10,11						X 0		X 0	X 0	X 0		4	4	6
White-throated Sparrow	5,6					X 0	X 0	X 0	X 0	X 0	X 0	X 0	8	8	12
Lincoln's Sparrow	5,6				X 0					X 0	X 0		3	3	4.5
Swamp Sparrow	3,6,8		X 0	X 0						X 0	X 0		4	4	6
Total species feeding		9	8	8	23	16	12	27	25	17	21	18			
Total species reproducing		6	7	9	22	17	13	29	25	18	21	17			

1/ Life form categories as defined in table 3.

2/ Snags or live trees are necessary for some species classified in this type.

3/ Index calculated by [2 (Reproduction stages) + Feeding stages] / 2.

4/ Species generally requires some coniferous component in this habitat type.

Disadvantages

1. Since systematic data is often lacking to quantify the species population levels within each successional range and to pinpoint the range of habitats occupied by each species, we were forced to make subjective judgements regarding a species classification. Such judgements are always prone to individual bias.
2. The approach also forces a subjective judgement of habitat classification when habitats themselves are difficult to classify. Obviously one may define more than 11 forest types in northeastern Minnesota. Many habitats, for example, are mixed associations resulting from such events as forest fire, logging, insect infestation, or natural disasters. Few forest stands are homogeneous cover types.
3. Realistically, we believe the successional approach is too simplistic and does not account for many factors that are important to the distribution of individual species.

LIFE FORM APPROACH

Background

The life form approach to wildlife management was recently introduced by wildlife biologists and foresters working in the Blue Mountains of northeastern Oregon and Washington (Thomas et al. 1975, Thomas et al. 1976). The approach was an attempt to develop a management model broad enough to be applicable to all vertebrate species and yet detailed enough to consider species-specific management issues. An additional criterion focused on the ability of the model to relate directly to present silvicultural practices. Because demands for timber production currently guide nearly all facets of forest management, it was important for wildlife managers to incorporate forestry concepts in their management models. Together these considerations led to the development of the life form approach to species management.

Similar to the guild concept used by avian ecologists (Salt 1957; Cody 1974), the life form is defined as an assemblage of species with similar reproductive and feeding strategies. For example, all birds that nest in shrubs and feed on the ground would be considered as belonging to one life form. The utility of the approach is based on the premise that species with similar habitat requirements will generally respond in a similar manner to habitat alterations. If shrubs were removed from a forest stand one would no longer expect to find shrub nesting species.

Alterations to the habitat are interpreted as changes that will either advance or retard a plant community's rate of succession. Logging, for example, will revert an upland stand back to a young herb-dominated community. A life form's response to such alterations represents the average response of all species within the particular life form category. A species response, in turn, is determined by examining its utilization of the major habitat types and successional stages in the region of interest. By summarizing the response of different species, the life form approach permits the wildlife manager and forester to manage for many species simultaneously, rather than the cumbersome task of initially having to consider each species separately. If needed, the data are also available for predicting the response of individual species.

Thomas and his co-workers considered several other factors in their life form model, such as a species use of special and/or unique habitats. A vulnerability index was also calculated to determine a species (or life form's) degree of adaptability or vulnerability to habitat manipulation.

Methods

We used the sixteen life form categories that Thomas et al. (1976) defined for their work in the Blue Mountains (table 3). The category or categories to which each bird species was assigned is shown in Table 2.

Each species utilization of plant communities in northeastern Minnesota was also determined (Table 2). Unlike the model of Thomas et al. (1975) which dealt separately with a species use of timber types and with its use of successional stages, we attempted to combine these responses by considering the eleven structural communities we previously defined. One reason we eliminated this separation was due to the small age spread for upland habitats in northeastern Minnesota and the corresponding lack of bird data across such fine categories.

Table 3. Life Form Definitions.[1]

Life Form 1:	Reproduces in the water and feeds in the water.
Life Form 2:	Reproduces in the water and feeds on the ground, in bushes or in trees.
Life Form 3:	Reproduces on the ground around water, feeds on the ground, in bushes or in water.
Life Form 4:	Reproduces on or in cliffs, caves, rim and talus slopes, feeds on the ground or in the air.
Life Form 5:	Reproduces on the ground, without specific water, cliff, rim or talus association, and feeds on the ground.
Life Form 6:	Reproduces on the ground, feeds in bushes and trees or in the air.
Life Form 7:	Nests in bushes, feeds on the ground, in water and in the air.
Life Form 8:	Nests in bushes, feeds in trees and bushes or in the air.
Life Form 9:	Nests primarily in deciduous trees, feeds in trees and bushes.
Life Form 10:	Nests primarily in conifers, feeds in trees and bushes, or in the air.
Life Form 11:	Nests in conifers or deciduous trees and feeds in trees or bushes, on the ground or in the air.
Life Form 12:	Nests on very thick branches, feeds on the ground or in water.
Life Form 13:	Excavates own hole, feeds in trees, brush or air.
Life Form 14:	Nests in a hole made by another species or in a naturally occurring hole-feeds on the ground, in water or in the air.
Life Form 15:	Reproduces in a burrow (underground) and feeds on or under the ground.
Life Form 16:	Reproduces in a burrow (underground) and feeds in the air or in the water.

Stands older than 60-70 years are scarce. In addition, because both upland and lowland habitats were considered in our model, we did not feel that the age boundaries nor the response of bird species for successional stages in uplands were necessarily applicable to the successional stages in lowlands.

With the bird data for each of the eleven habitats, we calculated a vulnerability index for each species (Table 2). As specified by Thomas et al. (1975), the index value was calculated by doubling the number of reproductive habitats the species uses, adding it to the number of feeding habitats used and dividing the sum by two. Although a species orientation to unique and or special habitats (e.g., snags, cliffs, etc.) may be included in the model, we did not incorporate such an analysis in this investigation.

Data Analysis and Interpretation

A major objective of the life form approach is to predict the response of vertebrates with similar habitat requirements to various habitat alterations. To illustrate, we examined life form 13 (species that excavate their own nesting cavities in a tree and feed either on the ground, in bushes, in trees or in the air). In northeastern Minnesota we identified eight species in life form 13 (Table 2). In addition to the woodpecker species, we have also included the boreal and black-capped chickadees. Although these chickadees may utilize either nesting cavities constructed by other species or natural cavities, they may also excavate their own (Harrison 1975). Based on the information in Table 2, the distribution of life form 13 in our eleven structural communities is shown in Figure 2. The figure provides the wildlife manager and forester with two types of information: 1) presence/absence information regarding the distribution of the life form within the communities; and 2) a means for predicting the impact of various habitat alterations. For example, the mature deciduous community satisfies the habitat requirements for a larger proportion of species in life form 13 than any other community. If a 50-year-old aspen stand were clearcut, one

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[1] From Thomas et al. (1976)

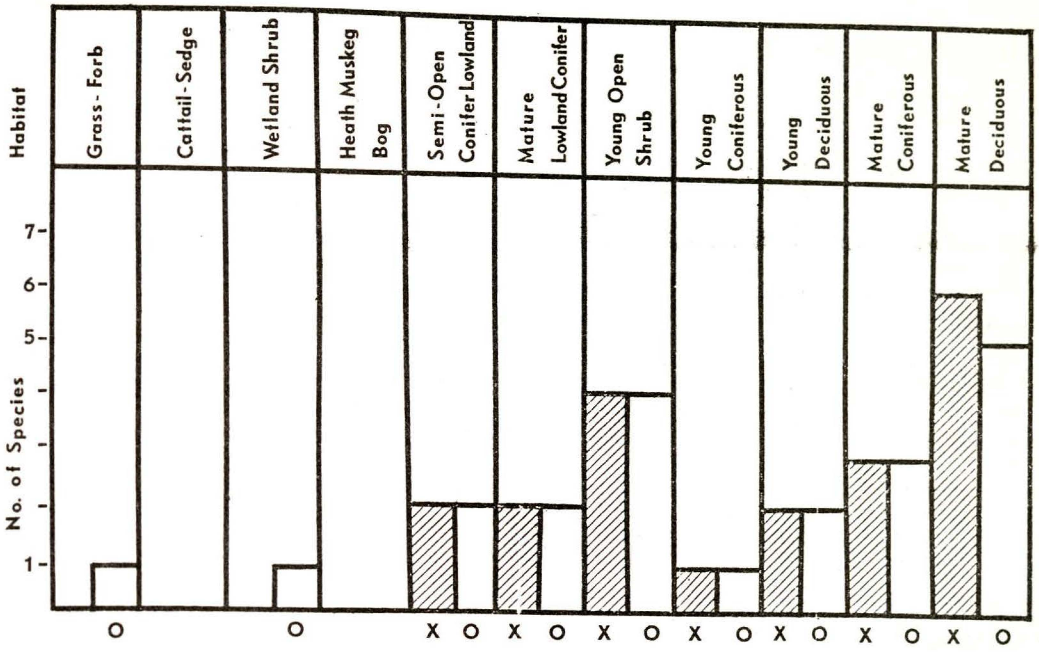


Figure 2.-- Distribution of Life Form 13 among the major habitats in northeastern Minnesota.
x= nesting 0=feeding

would predict a small decrease in the number of self-excavating cavity nesters, as long as some snags were left standing. If snags were removed, then the impact to cavity nesting species would be much greater.

Consideration of life forms provides helpful generalizations, but it is still important to consider the response of individual species. Information regarding species in life form 13 has been summarized in Table 4. An important question to consider when contemplating management alternatives is, 'Are some species within the life form more vulnerable to habitat alterations than other species?' Using the previous example, are there species within life form 13 that are so narrowly confined to the mature deciduous habitat that its loss would be detrimental to the species population in northeastern Minnesota? Our table indicates that the loss of the aspen stand might be more detrimental to the pileated woodpecker than to other species within the life form. Another important consideration is the availability of the particular habitat with regards to both time and space. Loss of a rare habitat is obviously more likely to be detrimental to a vulnerable species than the loss of an abundant habitat.

Advantages

1. The life form approach integrates the information available for each species into the framework of a single model. It's value in establishing a data base for all vertebrate species should not be overlooked.

2. Condensing species information into a "workable" number of life form categories permits the manager to consider many taxa simultaneously.

3. The life form approach is flexible enough to allow for the incorporation of new data.

4. The approach generates a "rough" index of a species (and life forms) vulnerability to habitat manipulation. Although the index is a valuable indicator for predicting species composition changes on a broad scale, neither the index, nor the entire management approach, were intended as more than initial steps when dealing with specific management problems.

Species / Habitat	Grass-Forb	Cattail-Sedge	Wetland Shrub	Heath Muskeg	Semi-open Conifer	Mature Lowland Conifer	Young open Shrub	Young Coniferous	Young Deciduous	Mature Coniferous Upland	Mature Deciduous Upland	Adaptability-Vulnerability
Common Flicker	o				x o						o	3
Pileated Woodpecker											x o	1.5
Yellow-bellied Sapsucker										x o	x o	3
Hairy Woodpecker							x o				x o	3
Downy Woodpecker							x o		x o		x o	4.5
Black-backed 3-toed Woodpecker					x o	x o	x o			x o		6.0
Black-capped Chickadee								x o	x o		x o	4.5
Boreal Chickadee					x o	x o					x o	4.5

Table 4. The distribution of species in Life Form 13 among the major habitats in northeastern Minnesota.

Disadvantages

1. The original classification of structural communities is subjective rather than objective. In addition, the biologist's decision concerning species utilization of a structural community for feeding or reproduction is also subjective. The manager must make a judgement which is subject to bias and which is based generally on a limited amount of available information.

2. When a species ecology is inadequately known, its' adaptability/vulnerability may be inaccurately judged - another reason why the model is intended only as an initial approach to impact analysis. For example, in our earlier illustration, the model predicts that the black-backed three-toed woodpecker is more adaptable to habitat alterations than other species in life form 13 - a prediction many ornithologists might dispute.

3. Many species may be classified in more than one life form category. In many cases, this probably reflects the insufficient data that is available to the ecologist, particularly with respect to feeding habits. On the other hand, the adaptability of some species is reflected by classifying them in more than one category.

MULTIVARIATE APPROACHES

One of the principal criticisms of the two approaches we presented above is their reliance on subjective judgements. Although these judgements were based on field experience and familiarity with the literature, a need clearly exists for more objective approaches to modeling natural systems. Such concern has prompted avian ecologists (e.g., James 1971; Whitmore 1977; Smith 1977) to investigate various multivariate approaches to avian community analysis. Multivariate techniques were implemented in the species association approach described below in order to analyze the relationships among species and in the habitat - niche analysis to analyze the relationships between species and their environment.

SPECIES ASSOCIATIONS AND AVIAN COMMUNITIES

Background

The following approach to community analysis implements multivariate techniques to classify avian communities and to delineate species associations within those communities. As we stated earlier, the classification of avian communities has, historically, been rather subjective (e.g., Kendeigh 1945; Martin 1960). Most avian ecologists have assumed that the "boundaries" of avian communities directly reflect the "boundaries" of plant communities. Though the plant community framework is satisfactory for a preliminary assessment, the wildlife manager should not assume that the same boundaries always apply to avian communities. Our intent was to derive a classification scheme for bird communities with the use of parameters that quantified the bird species composition rather than the plant species composition. Compared with the numerous studies using rigorous mathematical approaches to plant community classification (e.g., Grigal and Ohmann 1975; Nobles _et al_. 1977), few studies have dealt with such an approach to avian community classification.

The second objective of the association approach was to delineate species associations; a species association being a group of species that are distributed in a similar manner among avian communities. Few species, either plant or animal, are restricted in their occurrence to one community. Several species may often occur together in different communities because they require a similar environmental feature. Our objective was to characterize the bird species associations in northeastern Minnesota and to illustrate their occurrence and abundance within the different avian communities.

We chose cluster analysis (Boesch 1977; Pielou 1977) as the mathematical technique for defining avian communities and associations. The technique operates by combining sets of data, or entities, on the basis of their overall similarity. In this example the 'sets of data' corresponded to the set of avian population censuses for all study plots, while the 'entities' corresponded to each of the individual bird species. The degree of similarity among plot censuses, or among the distribution of individual species, was mathematically interpreted as the distance between sample points. The clustering process may be graphically represented by a dendogram which illustrates the hierarchial arrangement of the data sets or entities (e.g., see Cody 1974).

Cluster analysis operates under the assumption that the sample units naturally fall into discrete and recognizable communities. The validity of this assumption however, has been challenged by ecologists who allege that discrete discontinuities between communities are not realistic (e.g., Gleason 1926; Curtis 1959). Those ecologists who maintain that species are geographically distributed independently of one another favor the use of ordination techniques that graphically portray the relationships among sample stands. Ordination arranges the stands within a uni-dimensional coordinate frame so that the relative continuity or discontinuity in their distribution is illustrated. The ordination technique commonly used for this purpose is discriminant analysis. Discriminant analysis operates by defining linear combinations of the components of each stand (e.g., species) so that, within a coordinate frame, the distances between communities are maximized. In avian ecology, discriminant analysis has recently been used by several authors to graphically illustrate the distribution of individual species (James 1971; Whitmore 1977; Smith 1977; Thomas _et al_. 1977). We have implemented discriminant analysis to portray the degree of similarity/dissimilarity among the species composition of the different study plots.

Methods

The procedures for implementing cluster analysis were applied to avian census data collected in 43 forest stands. The sample stands were selected to represent the portions of all major cover types in northeastern Minnesota. Territory mapping (Williams 1936) was selected for collecting census data from each plot during the 1977 summer season. Although we will briefly review our analysis procedures in the following paragraphs, Pfannmuller (1979) should be consulted for further details.

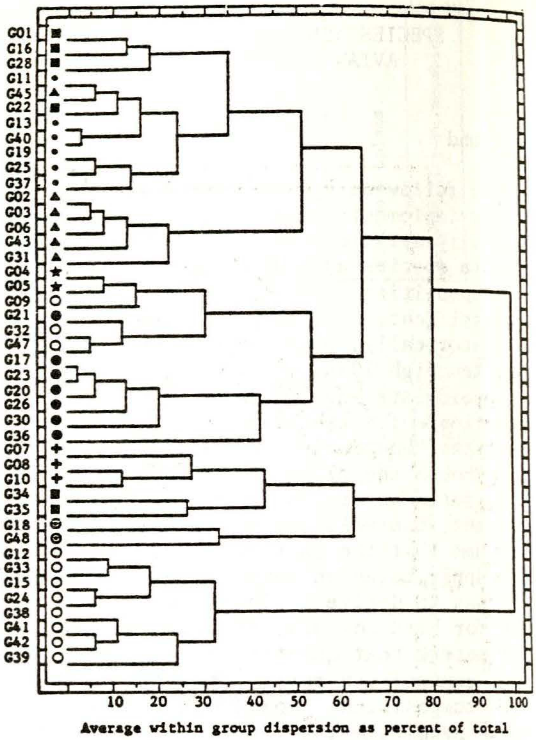
In order to define both the avian communities and species associations that characterize northeastern Minnesota, we needed to implement the technique of cluster analysis in two different ways. The first, referred to as normal analysis, (Boesch 1977) was used to classify communities. Normal analysis grouped together the 43 sample stands on the basis of their overall similarity in bird species composition. For example, we would predict that the bird censuses from two mature jack pine stands would be recognized as representing one avian community. Discriminant analysis was also applied to graphically portray the 'distance' or similarity in the avian composition of the sample stands. The second type of cluster analysis, referred to as inverse analysis (Boesch 1977), was used to define species associations. Inverse analysis grouped together bird species that showed similar distribution among the 43 sample stands. For example, we might predict that the red-eyed vireo and ovenbird, species that are both commonly observed in mature upland forest stands, would be members of one species association.

Computer programs designed to conduct cluster analysis were written by E.J. Cushing of the University of Minnesota and by G. Burnett, of the State of Minnesota (State Planning, Regional Copper-Nickel Study). The input variables for the program, and the distance equations for computing similarity, were systematically altered by the authors. Further details can be found in Pfannmuller (1979).

Data Analysis and Interpretation

By varying both the nature of the input variables and the distance equations, several dendrograms were generated with normal cluster analysis; one such example is shown in Figure 3. The figure clearly suggests an appropriate scheme for classification. For example, the bird species composition in eight of the eleven deciduous upland plots was recognized as similar and they were distinct from the species composition on the remaining thirty-five sample plots. It is appropriate at this point to advance a warning - the ecologist should not interpret the classification suggested by any one dendrogram as definitive. Rather, all dendrograms generated from normal analysis should be analyzed before proposing a reasonable classification (which may not directly reflect any one particular dendrogram). Based on the 1977 breeding bird data, nine avian communities were delineated for northeastern Minnesota (see Fig. 5). A graphical illustration of the similarity of their species composition is shown in Figure 4. Several dendrograms were also generated from inverse cluster analysis. Although we have not included any of the dendrograms here, the final classification of species associations is detailed in Table 5. In addition, the relative abundance of the species associations in each avian community is illustrated in Figure 5.

The delineation of avian communities with the use of dendrograms suggests structural features of the vegetation that are important to birds in northeastern Minnesota. For example, the avian composition of mature deciduous uplands was recognized as distinctly different from the avian composition of mature coniferous uplands. Therefore, a major structural distinction important to many species in their selection of a breeding habitat was the distinction between deciduous and coniferous vegetation. However, the distinctions between different deciduous cover types or different coniferous cover types were apparently not important to birds. The species composition of mature red pine stands, for example, were not recognized as faunistically distinct from the species composition of mature jack pine stands. The community in Figure 4 also



Key to major vegetation cover types on each plot:

■ **Young plantation**

• **Recent Clearcut**

▲ **Conifer lowland**

○ **Deciduous upland**

★ **Disturbed shrub**

● **Conifer upland**

✚ **Aspen regeneration**

⊖ **Alder**

Figure 3.--Dendrogram showing the hierarchial relationships among bird communities of 43 stands based on the density of 56 breeding bird species.

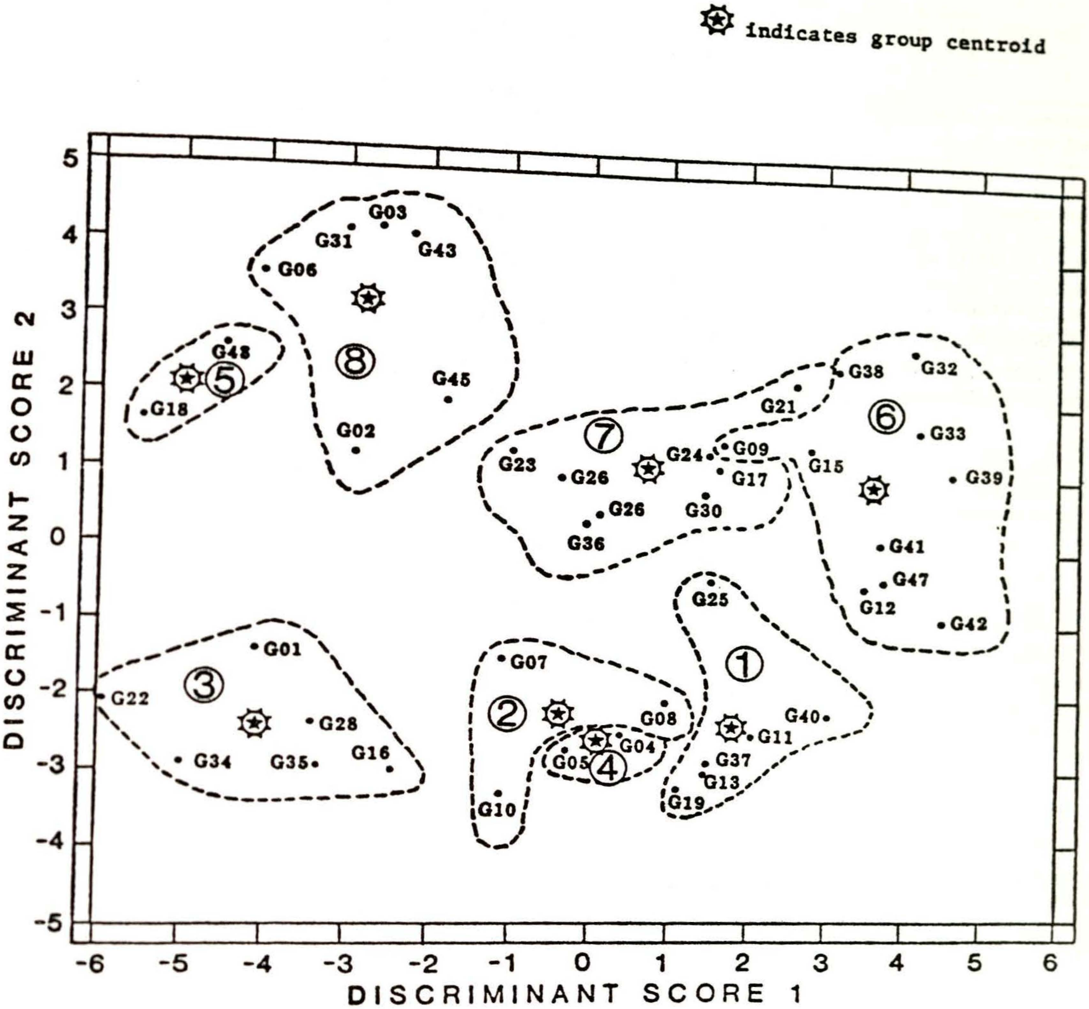


Figure 4.--Spatial relationships of bird communities on 43 of the 1977 sites when plotted using 2 discriminant functions.

provides the wildlife manager with important information. The ordination graphically portrays the degree of community "distinctness." The greater the distance between the centers of each cluster, the larger the difference in species composition.

By examining the relative abundance of the species associations within the bird community we can also generate information regarding the relative "distinctness" of the communities. The alder bird community, for example, is unique in it's abundance of species belonging to the gray catbird/swamp sparrow species association. In addition, we can see that members of this association have a narrower tolerance of different habitats than members of the mourning warbler/chestnut-sided warbler association. As with any model of a natural system, the larger the number of sample stands that are included in the original data base, the stronger are the predictions that the model can make.

Advantages

1. The approach recognizes avian communities on the basis of avian attributes rather than forcing avian community boundaries into the boundaries of vegetation communities. It thereby demonstrates similarities among avian communities that may not be intuitively obvious from a vegetation analysis alone.

Table 5. -- Species composition of the 9 major bird species associations in northeastern Minnesota.[1]

I. Mourning Warbler/Chestnut-sided Warbler	II. Red-eyed Vireo/ Ovenbird	III. Common Flicker/Brown-headed Cowbird
Blue Jay Robin Cedar Waxwing Black-and-white Warbler Nashville Warbler Magnolia Warbler Chestnut-sided Warbler Mourning Warbler	Yellow-bellied Sapsucker Least Flycatcher Red-eyed Vireo Ovenbird Canada Warbler Rose-breasted Grosbeak	Common Flicker Great Crested Flycatcher Alder Flycatcher Tree Swallow Golden-winged Warbler Brown-headed Cowbird
IV. Black-capped Chickadee/ Golden-crowned Kinglet	V. Gray Catbird/Swamp Sparrow	VI. Yellow-bellied Flycatcher/ Connecticut Warbler
Spruce Black-capped Chickadee Brown Creeper Golden-crowned Kinglet	Killdeer Ruby-throated Hummingbird Gray Catbird Red-winged Blackbird Swamp Sparrow	Gray Jay Yellow-bellied Flycatcher Winter Wren Ruby-crowned Kinglet Cape May Warbler Connecticut Warbler
VII. Sparrow Hawk/Brown Thrasher	VIII. Hermit Thrush/ Blackburian Warbler	IX. Eastern Wood Pewee/ Scarlet Tanager
Sparrow Hawk Brown Trasher Brewer's Blackbird Lincoln's Sparrow	Hermit Thrush Solitary Vireo Yellow-rumped Warbler Blackburnian Warbler Evening Grosbeak Dark-eyed Junco Chipping Sparrow	Eastern Wood Pewee Red-breasted Nuthatch Black-throated Green Warbler Scarlet Tanager American Goldfinch

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[1] The strength of the relationships among the species in each association is dependent upon: 1) the amount of information available for each species and 2) the range of habitat tolerance for each species. The weaker associations in the above table include associations IV, VII and IX; all represent species that were relatively uncommon.

2. Because the boundaries of vegetation and avian communities are often similar, one can predict the relative importance of various structural features of the vegetation upon the composition of avian communities.

3. The species composition of bird communities are characterized by the relative importance of different species associations. Each species association is composed of species with similar habitat distributions.

4. Discriminant analysis allows the wildlife manager to graphically perceive the degree of faunal distinctness among the bird communities.

Disadvantages

1. Although broad vegetational requirements of a species are defined, information regarding specific niche dimensions are lacking. Data of this form are necessary prerequisites to species-oriented habitat management.

2. The technique has not been widely applied.

3. Some subjective judgements are still involved in the classification of communities and associations.

4. As was indicated in Table 5, the strength of the classification, for species associations or communities, depends on the amount of data available. For example, the strength of a species association that includes several uncommon or rare species may be less

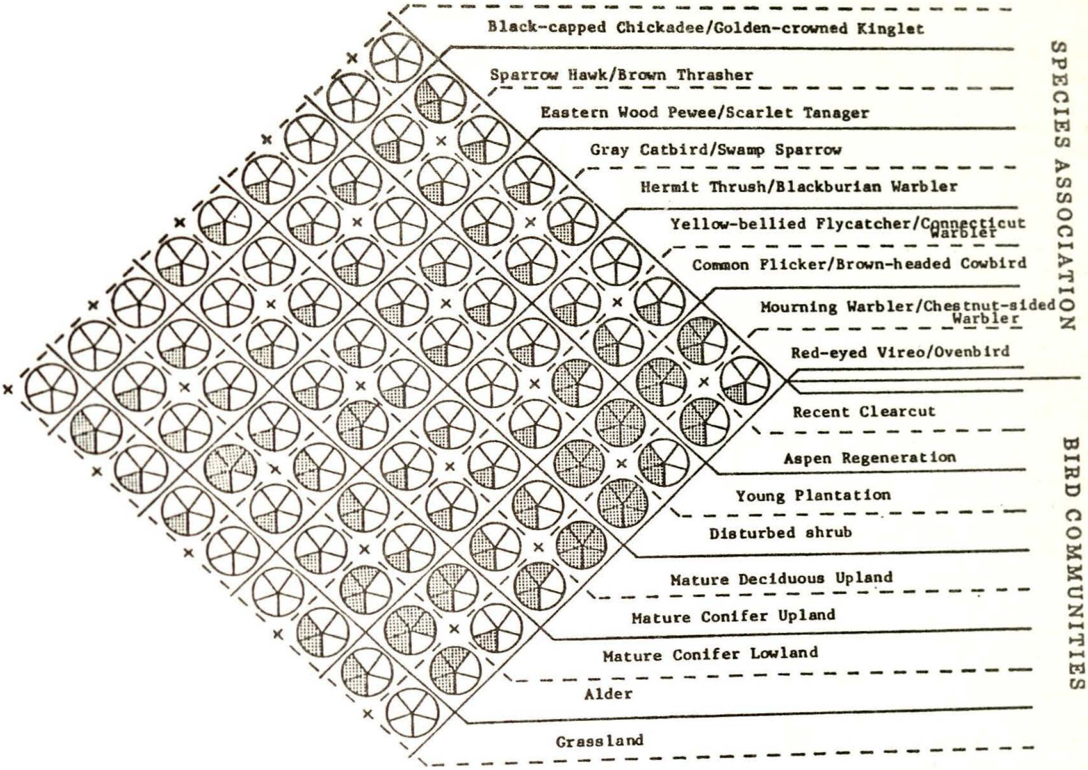
Black-capped Chickadee/Golden-crowned Kinglet
Sparrow Hawk/Brown Thrasher
Eastern Wood Pewee/Scarlet Tanager
Gray Catbird/Swamp Sparrow
Hermit Thrush/Blackburian Warbler
Yellow-bellied Flycatcher/Connecticut Warbler
Common Flicker/Brown-headed Cowbird
Mourning Warbler/Chestnut-sided Warbler
Red-eyed Vireo/Ovenbird
SPECIES ASSOCIATION
Recent Clearcut
Aspen Regeneration
Young Plantation
Disturbed shrub
Mature Deciduous Upland
Mature Conifer Upland
Mature Conifer Lowland
Alder
Grassland
BIRD COMMUNITIES

Figure 5.--The relative abundance of major species associations within bird communities of northeastern Minnesota.

(i.e., less stable) than an association that includes several abundant species.

HABITAT NICHE ANALYSIS

Background

Like the previous approach, this technique is a multivariate approach that relates habitat variables to bird distributions. Most naturalist's have recognized for a long time that certain birds occur in particular environments (Adams 1908). Some species may respond to one particular factor while others may respond to a combination of factors, thereby illustrating the need for multivariate techniques. The multivariate approach to habitat selection, and more specifically to the niche concept, was formalized by Hutchinson (1965). Hutchinson viewed the niche as an n-dimensional Euclidean space with each axis of the space corresponding to some relevant variable in the species biology. This approach has been used by Shugart and Patten (1972), Anderson and Shugart (1974), Shugart _et al_. (1975), Whitmore (1975), and Noon and Able (1978).

The basic premise of the approach assumes that the habitat selected by birds can be measured mathematically (see Green 1971b, 1974). If we assume that it is possible to accurately measure all niche habitat components, then it is possible to mathematically predict the probability that a species will occur in a given habitat. A key to understanding this approach involves viewing the space a species occupies as a hyperellipsoid because the individual components that define the niche are intercorrelated. For example, the density of trees directly effects the density of shrubs and herbs. Such correlations between components of the habitat implies that graphically, their axes are not orthogonal (i.e., they are not independent of one another). Subsequently, to make predictions from field data, a new coordinate system must be defined such that the axes are orthogonal or independent. These new independent axes are simply linear combinations of the original data set.

For this paper we have used principal component analysis (PCA) as modified from the work of Niemi (1977). PCA is a rotation of coordinates into a sampled hyperellipsoid. The principal component coordinates are independent and explain decreasing amounts of variation in the sample data. In PCA, a series of habitat measurements (vectors) are made within an area occupied by a species. These measurements essentially quantify the amount of a given habitat variable (e.g., tree density) that appears necessary to provide suitable habitat for the species. With an appropriate number of samples, a mean vector position or "centroid" can be calculated for each sample vector. In general, for a given habitat, the closer a habitat vector is to the species centroid position, the more suitable the habitat is for the species. A probability model can be designed to predict the occurrence of a species within a given habitat. These predictions are based on measurements of the same habitat variables used to establish the specific model. Such a model may also allow interpretation of species preference both within and between habitats (Shugart _et_ _al_. 1975).

Method

We will briefly explain the methodology, but a more detailed description can be found in Niemi (1977). We constructed a model based on a PCA analysis of eight measured habitat variables (Table 6) collected within the territorial boundaries of 21 bird species found in northeastern Minnesota. These bird and habitat data were collected in four different stands during June and July of 1974 and 1975. Three stands were in young altered habitats while the fourth stand was in a mature forest habitat. The three altered stands consisted of: 1) a burned, virgin jack pine stand (BVP) which was never logged but burned in 1971, 2) a burned, cut jack pine stand (BCP) which was logged and then burned in 1971, and 3) an aspen clear-cut (ACC) stand which was logged in 1973. The mature stand was a mixed balsam - birch forest (BBF) with some aspen. These habitats were selected to demonstrate the microhabitat preferences of bird species within early successional stages and to show how a principal component model can be useful to compare changes occurring in bird populations following alteration.

Data Analysis and Interpretation

The principal component model is shown in Figure 6. The figure clearly delineates a group of species to the right, that are typically associated with mature forests, and species to the left, that are typically associated with early successional stages. Table 7 shows the correlation of the original habitat variables with the principal components for proper interpretation of the axes of the model. Those species between the two groups, such as the red-eyed vireo, veery, blue jay, and least flycatcher, are typically associated with a wide variety of habitats ranging from the early successional stages to the mature forest stages. Within the species group associated with the early successional stages, there is a noticeable gradient of species preferences from the common yellowthroat on top to the hermit thrush at the lower left (Figure 6). The yellowthroat prefers the open areas in the early successional stages along with a high density of low shrubs, and a low density of saplings and trees. The hermit thrush, however, prefers areas with high tree and sapling densities. Many species are rather ubiquitous in the early successional

Table 6.--Description of 8 variables used in the principal component analysis shown in Figure 6 including mnemonic code and method.

Variable Mnemonic	Description	Method
GC	Percent ground cover divided by 10	20(+ presence or-absence readings of green vegetation (James and Shugart 1970)
HS	High shrub density	Number of shrub stems >1m. high <2.5cm dbh/10^{-3}ac. (Ohmann 1973)
LS	Low shrub density	Number of shrub stems >.3m high <1m. high/4x10^{-3}ac. (Ohmann 1973)
SH	Shrub height	Average of 4 readings in m./10^{-1}ac.
SLOP	Slope	Change in elevation for diameter of 10^{-1}ac. circle
SDIV	Shrub diversity	Shannon and Weaver (1963) diversity index
SAPS	Sapling density	Number of saplings 2.5-7.6cm dbh/ 10^{-1}ac.
T2	Tree density	Number of trees 15.1-22.9cm dbh/ 10^{-1}ac.

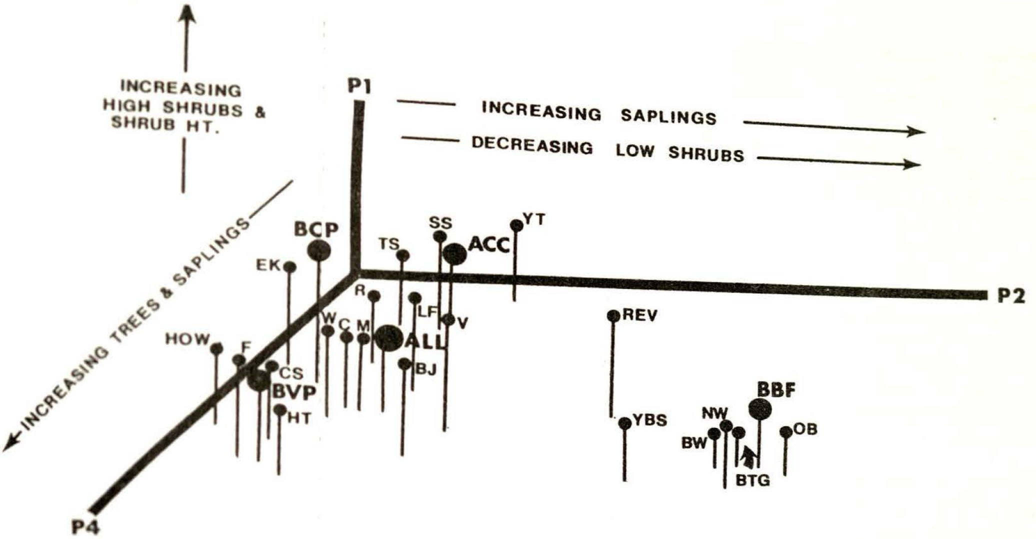

Figure 6.--Mean principal compoent vectors for twenty-one bird species and four sampled stands (described in text) on the best three principal components separating species habitat. Each axis is an orthogonal component composed of linear combinations of the eight habitat components shown in Table 7. Species include common flicker (F), yellow-bellied sapsucker (YBS), eastern kingbird (EK), least flycatcher (LF), tree swallow (TS), blue jay (BJ), house wren (HOW), American robin (R), hermit thrush (HT), veery (V), red-eyed vireo (REV), nashville warbler (NW), black-throated green warbler (BTG), blackburnian warbler (BW), chestnut-sided warbler (C), ovenbird (OB), mourning warbler (M), common yellowthroat (YT), chipping sparrow (CS), white-throated sparrow (W), and song sparrow (SS).

stages, such as the chestnut-sided warbler, mourning warbler, and white-throated sparrow; they tend to cluster around the mean position for all (ALL) the altered habitats.

One of the interesting discoveries of this study regards an index value (Z value, Table 7) that was calculated to test the relative strength of each principal component to separate the habitats selected by species. We found that although each principal component explained a decreasing amount of variation in the habitat data (Table 7), those same components did not necessarily explain decreasing amounts of variation in the bird species selection of habitats. The descriptive model was constructed by using the best three principal components which separated species habitat, not habitats alone. Birds may not differentiate between habitats based simply on those variables with high variations, but rather on variables which provide the best discriminating cues between habitats, variables which provide a specific need, or for other more subtle reasons. Thus, in Figure 6 and Table 7, P2, P4, and P1 were ordered for best separating species habitats while P1, P2, and P4 were ordered in explaining variation in the habitat data.

Figure 6 provided a means to view multiple species habitat selection by multiple measurements of structural habitat components. These measurements could also include additional niche components such as food requirements, or other behavioral traits which more accurately define a species niche hyperspace. We have used principal component analysis, but discriminant function analysis may also be used to maximize the separation between species groups (James 1971; Shugart and Patten 1972; Shugart et al. 1975). Further sophistication of multivariate analysis and a more thorough testing of its field methodology will eventually provide better techniques for use in practical applications.

Advantages

1. A multivariate perspective can potentially allow a large number of species to be considered simultaneously in management objectives.

2. Presuming the assumption for collecting data are appropriate, this approach can ultimately test the strength of species associations (e.g., how closely associated are

species in a defined community) and provide a measure of the niche breadth of specific species.

3. Subjective judgements are substantially minimized relative to the approaches listed above.

Disadvantages

1. Unless an intimate understanding of both multivariate procedures and wildlife species requirements are obtained by users, these techniques may be improperly interpreted and easily abused.

2. By using the multivariate techniques, interpretation of species habitat preferences are more difficult and abstract.

3. Whether niche requirements are measurable is questionable. Presumably, there are many intangible factors which are difficult to quantify but important to the well-being of a species. See final discussion for more details.

DISCUSSION

We briefly examined four broad and diverse techniques that ecologists have implemented in their efforts to describe the relationship between animal species and their environment. We have chosen the four models presented above because they portray, in our estimation, the most realistic approaches currently available for managing many species simultaneously. A brief summary of the philosophy supporting each approach was presented, a short discussion of it's methodology, and an example of it's application. Several brief statements were also made regarding the relative merits and drawbacks of each approach. The discussion of each approach was of necessity rather general.

Giving any of the approaches justice, however, should include a detailed review of the publications cited. Hopefully our summary has provided a general review of each approach and has demonstrated that none of the techniques will provide the wildlife biologist with an all encompassing approach to species management. Since it is almost a classic response that most scientific investigations reveal far more problems than they answer, we feel it is important at this point to outline many of the problems that continually frustrate wildlife biologists who attempt to answer seemingly simple questions regarding wildlife distributions. The items listed below are drawbacks that are generally inherent to all multi-specie approaches to habitat management:

Table 7.--Z values, explained variation, and correlation coefficients of the eight habitat variables associated with the three principal components used in Figure 6. Mnemonic habitat codes are from Table 6.

	Principal Components		
Z value 1/	P2	P4	P1
Exp. Var. 2/	46.	17.	10.
Correlations 3/	21.	14.	26.
GC	.27	-.14	.39
GS	-.45	.27	.84
LS	.67	-.57	.55
SH	-.28	.27	.73
SLOP	-.02	-.20	.09
SDIV	.37	-.09	.43
SAPS	.43	.64	.29
TS	.24	.63	-.01

1/ A measure of relative strength of the principal component to separate species habitat as described in text.

2/ Variation explained by the principal component with respect to the habitat data.

3/ Correlation coefficients of the principal components with the original habitat variables.

1. The delineation of communities, either plant or animal, is questionable. All but one of the models described above incorporated a subjective judgement regarding community boundaries. It is sufficient to note that some form of classification is necessary only from the perspective of human communication, but any static classification seems useless.

4. Habitat selection by birds may be partially controlled by factors beyond those that can be measured within an individual's territory or home range. The size of a habitat (Whitcomb 1977, Diamond 1975) and it's spatial relationship to other habitats (Leopold 1932, Wiens 1975) are factors which

have received little attention from avian ecologists. Such factors, however, may be important components in the habitat selection process. For example, what size should clearcuts be to maintain natural populations and how should they be juxtapositioned with other habitats to benefit wildlife or a particular species?

3. Generalized approaches to wildlife management, such as those presented above, often do not take into account special habitat requirements of some species. Such democratic techniques, which manage for the "majority," may be extremely detrimental to species with specific requirements. Snags, the unmeasured variable described by Balda (1975), is an example of a neglected yet important habitat requirement for many birds. DeGraaf (1978) recently estimated that among the 800 bird species found in the United States approximately 85 are cavity nesters. For many species such as these, the absence of a single feature in the habitat could critically reduce population levels. It is crucial that potential 'limiting factors' be identified.

4. Wiens (1977) has recently summarized a concept called "ecological crunch" whereby species experience population fluctuations in response to changing environmental conditions. During times of resource limitation or stress (e.g., during drought), species may become restricted to their optimum habitats-habitats where their behavioral and morphological adaptations are best suited for securing resources. In response to these limitations, population levels may be greatly reduced. During resource abundance, however, species diffuse into submarginal habitats and, consequently, their population levels increase. This emphasizes the importance of long term studies of species populations - studies which, to date, have been seriously lacking.

5. The factors that limit population levels are poorly understood. Although most bird population studies have been conducted during the breeding season, there is a growing concern that events on the wintering grounds may be the most important factors influencing bird populations (Lack 1971), Fretwell 1973). Once again long term investigations that cover the entire life history of the species, from it's breeding grounds, to migration resting areas, and finally to wintering grounds, have been neglected.

6. A realistic approach to wildlife management must establish a means to limit the species under consideration in order to be workable. Although we have attempted such a procedure here, an important question remains - how can a wildlife manager objectively (not subjectively, as we have) decide which species to include in his management plan? The federal endangered species list, state threatened or endangered species lists, and the American Birds Blue List provide some direction for identifying species of concern. Nevertheless, these lists are also subject to individual bias and are rarely substantiated by systematic field investigations. The entire concept of "uniqueness" has escaped a much needed quantitative definition. Uniqueness criteria are difficult to define and an evaluation does not exist. Should species uniqueness be determined by niche breadth, distribution, public opinion, importance to man, importance to the ecosystem, or some other criterion? Environmental evaluations using birds and habitats, such as that presented by Graber and Graber (1976), have been progressive in this regard and deserve further attention.

7. Many ecological concepts have not been included in the models discussed above. Included among these concepts are predator-prey relationships, competition, and diversity. Until their importance is fully understood, any approach to wildlife management will, of necessity, be "simplistic" in nature.

In listing these drawbacks we do not wish to frighten wildlife biologists who endeavor to implement management approaches such as the ones we have presented here. By their very nature, all models are beset with limitations. Their objectives are to simplify natural systems, to identify the major components of the system, and to determine the species ultimate dependence upon one another, Nevertheless, we are better prepared to employ the practical applications of such models when we understand their inherent limitations.

The four approaches to non-game bird management that we have presented will serve as a framework to be expanded as our data base grows. At present we need to continue research efforts that are designed to identify species habitat requirements. Nevertheless, we have reached a starting point for wildlife impact analysis. Although we are still far from the point where the impacts of all habitat management problems can be accurately predicted, non-game bird managers can predict gross population changes based on the data we have presented.

All four management models have also been effective methods of data reduction. Beginning with an extensive list of variables that quantify the environment, principal component analysis has, after linearly combining the variables, identified those that are best able to define the response of different species in the community to environmental parameters. Features of the habitat are thereby reduced to a few 'components' that are important in the species distributions. The successional stage, life form, and species association models have, by different techniques, identified various assemblages of species. The assemblages include species which by various methods, are recognized as responding to the environment in a similar manner. As a result, the biologist can deal with groups of species rather than individual species. Work at effective methods of data reduction must continue if non-game biologists are to effectively communicate pertinent information to foresters which will aid them in understanding the implications of various habitat management alternatives.

CONCLUDING REMARKS

There are many approaches to wildlife management. The four we have examined are attempts to construct models that will simultaneously examine many species. Although the successional stage and life form approaches establish an important data base for each species, when the habitat requirements of hundreds of vertebrate species is considered, the problems are nearly incomprehensive. Thus, if managers realistically want to consider all vertebrates in the planning process, the necessity for using some form of multivariate analysis is essential. Such analyses are useless, however, unless they can be comprehended by the ecologist and wildlife manager alike. Bridging the gap between theoretical and applied ecology is not an easy task and may prove to be one of our most challenging tasks. The manager who attempts to put ecologist's models to practical use must be able to perceive how generalizations derived from the model relate to the real system he manages. In time, it would be beneficial for either theoretical ecologists to attempt interpretations of their data for practical use or a concerted effort be made to integrate theoretical findings into practical management approaches.

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THE IMPORTANCE OF WETLANDS IN THE NORTH CENTRAL AND NORTHEAST UNITED STATES TO NON-GAME BIRDS

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Abstract.--Over 200 migratory and year-round resident bird species use the diverse but limited wetland areas of the northeast and north central United States for part or all of their life requirements. Non-game and minor game (rails, coots) bird use is discussed by wetland type for both regions. Problems and causes of wetland and water bird decline are discussed; and management recommendations for wetlands and forest managers are set forth.

INTRODUCTION

Wetland areas of the north central and northeast regions of the United States offer diverse habitats of great importance to many wildlife species, including over 200 migratory and year-round resident bird species. Nesting and feeding are the primary uses, but cover, resting, and breeding/staging uses are important. Most of these species are non-game, and have not been as intensively studied as game bird species. Over the years, however, numerous books and papers have been written in which non-game bird use of wetlands in the northern states was noted (Adams et al. 1973; Anderson 1978; Anderson and Hamerstrom 1967; Audubon 1844a and 1844b; Beecher 1942; Bent 1921 and 1926; Berger 1951; Bergman et al. 1970; Burger 1974; Burger 1977a and 1977b; Custer and Osborn 1977; Downing 1975; Golet and Larson 1974; Gromme 1963; Hardy 1957; Harris and Matteson 1975; Hill 1965; Johnson 1977; Kadlec and Drury 1968; Landin 1978a, 1978b, and 1978c; Martin et al. 1951; Moseley 1936; Nicklaus 1977; Palmer 1962; Partch 1972 and 1975; Scharf 1977; Shaw and Fredine 1956; Soots and Landin 1978; Thompson 1977; Thompson and Landin 1978; Weller and Spatcher 1965; and many others). These papers tend to emphasize large water and marsh birds rather than the many smaller passerine species that also use wetlands. Some of the more informative papers which mention non-game bird use in the northern United States have been environmental impact statements prepared for or by the Corps of Engineers for various reaches of the Mississippi River system, the Great Lakes, and other parts of the northern states (Miller and Krumm 1973; Nordstrom et al. 1974; River Studies Center 1975; Terpening et al. 1975; U. S. Army Engineer District St. Louis 1975; and U. S. Army Engineer District St. Paul 1974) and by the U. S. Energy Research and Development Administration (Wallace 1977).

The wetlands of these two regions are as varied as the avian wildlife that use them (Shaw and Fredine 1956). Such a large area, covering 19 states from Minnesota to the north Atlantic coast and from the Great Lakes to Chesapeake Bay and the mid-Mississippi River, can only be discussed by the use of generalities. The regions have within them a number of distinct wetland types which are discussed later in this paper.

Historically, the wetland areas of both regions were much more extensive than the present day wetlands (Niering 1966). The northeastern salt marshes have been altered greatly since the early 1700s, and the interior Great Lakes marshes, fresh water swamps, and river systems have faired little better. The only areas that resemble their former expanses are the prairie pothole areas of the north central states (Stewart and Kantrud 1971), which is largely due to the intense and active interest shown in these areas by waterfowl hunters. Shipping, urbanization, recreation, flood-control, and agricultural uses are responsible in most cases for these wetland losses (Shaw and Fredine 1956). Shaw and Fredine (1956) reported only 750,834 hectares remaining in all wetland types in the northeastern states and only 4,627,820 hectares remaining in the north central states in 1956. Wetland losses have continued to occur since that time at a slower pace (Conservation Foundation 1978), but is still taking place. Wetland hectares will continue to be nibbled away because they are owned by private citizens, are not protected in all areas, and are in fringe areas which will cause them to be destroyed through changes in the surrounding environment in spite of efforts by many concerned groups to protect and manage the remaining wetlands.

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WETLAND TYPES

Shaw and Fredine (1956) described a wetland classification system that has now been outdated by the new operational draft U. S. Fish and Wildlife Service classification system of 1978 (Cowardin et al. 1977). Golet and Larson (1974) classified northeastern interior wetlands and Stewart and Kantrud (1971) did the same for the prairie pothole wetlands. For purposes of discussing bird use of these wetlands, a modification based on Shaw and Fredine (1956), Golet and Larson (1974), and Stewart and Kantrud (1971) has been devised and is used throughout this paper. Under this system, there are ten wetland types in the northeast and north central United States that are used by non-game and minor game birds during some phase of their life cycle: feeding, resting, nesting, breeding or staging, and migration.

Open Fresh Water

This wetland type is permanent fresh water 1.0-3.0 meters deep, such as ponds, lakes, rivers, and streams. It is almost always associated with other wetland types. Non-rooted aquatic macrophytes such as pondweeds (Potomogeton spp.), coontail (Ceratophyllum demersum), fanwort (Cabomba caroliniana), and other fresh water submergents, as well as duckweeds (Lemna spp.) in stillwater areas, are the usual plant species encountered in these habitats. They are used by migrating waterfowl, loons, grebes, cormorants, and coots for feeding and resting (Thompson and Landin 1978; Golet and Larson 1974). They are also used as feeding areas by fish-eating raptors, gulls, and terns (Ludwig 1968).

Deep Fresh Marsh

Permanent water areas 0.2-1.0 meters deep in areas of low energy that allow establishment of rooted aquatic plants characterizes this wetland type. This type frequently borders open water, and supports the above listed species as well as floating-leaved plants such as white water lily (Nymphaea odorata), watershield (Brasenia schreberi), and water smartweed (Polygonum amphibium). A few emergents such as cattails (Typha spp.) will occur in the shallower areas.

In addition to being the most valuable habitat for waterfowl, this type is very important to many species such as loons, grebes, and coots. It is also frequented by feeding bitterns, herons, and egrets in its shallower spots and dense floating mats. Franklin's gulls (Larus pipixcan), Forster's terns (Sterna forrteri), black terns (Sterna nigra), and American coots (Fulica americana) will seek these areas for nesting (Burger 1974; Thompson and Landin 1978).

When shrubs such as buttonbush (Cephalathus occidentalis) and willow (Salix spp.) occur in a deep marsh, the area is also used for nesting by red-winged blackbirds (Ageuaius phoeniceus) and yellow-headed blackbirds (Xanthocephalus xanthocephalus), and by small passerines for feeding and resting.

Shallow Fresh Marsh

This type of wetland is also highly valuable to waterfowl species for feeding, resting, and nesting. It is usually permanent water less than 0.2 meters deep, and is vegetated with cattails, wild rice (Zizania aquatica), bulrushes (Scirpus spp.), some sedges (Carex spp.), water willow (Decodon verticillatus), common reed (Phragmites australis), and other robust emergents (Golet and Larson 1974; Environmental Laboratory 1978). Shallow marshes are very important as nesting and feeding areas for red-winged blackbirds, yellow-headed blackbirds, swamp sparrows (Melospiza georgiana), and other passerines (Martin et al. 1951); for minor game water birds; common gallinules (Gallinula chloropus), soras (Parzana carolina), Virginia rails (Rallus limicola), king rails (Rallus elegans), American coots, and common snipes (Capella galinago); spotted sandpipers (Artitis macularis); and for all of the heron, egret, and bittern species (Hoffman 1978) which occur in the north central and northeast regions. Protected shallow marshes are also used by Forster's terns, black terns, common terns (Sterna hirundo), herring gulls (Larus argentatus), and ring-billed gulls (Larus delewarensis) for nesting if sufficient large vegetation is available for nest substrate and material (Burger 1974; Scharf et al. 1978).

Shallow marshes will frequently have some shrubs, usually buttonbush and willow. These shrubs, if not too dense, enhance wildlife value by increasing habitat diversity in the marsh.

Seasonally Flooded Flats

Bottomland and floodplain areas which flood more than 12 centimeters deep, usually in late fall, winter, and spring, are characteristic of this wetland type. In the summer there is little or no standing water. In this wetland type, a herbaceous cover of smartweeds (Polygonum spp.), sedges, and nutsedges (Cyperus spp.) abounds during the growing season, as well as cattails, soft rush (Juncus effusus), reed canary grass (Phalaris arundinacea), and loosestrife (Lythrum spp.). These plant communities are used by waterfowl and other ground nesting marsh birds for nesting. If a seasonally flood-wetland becomes wooded (a shrub flat or bottomland hardwood), it will become useful to tree and shrub nesting species such as colonial waterbirds and many passerines. Climax trees in such a forest include American elm (*Ulmus americana*), silver maple (*Acer saccharinum*), swamp white oak (*Quercus bicolor*), pin oak (*Quercus palustris*), eastern cottonwood (*Populus deltoides*), and others. Intermediate plant species include willows, dogwoods (*Cornus* spp.) buttonbush, meadow-sweet (*Spiraea latifolia*), and red maple (*Acer rubrum*).

The presence of several life forms in this type of wetland increases its value, and many passerines such as yellowthroats (*Geothlypis trichas*), song sparrows (*Melospiza melodia*), swamp sparrows, yellow warblers (*Dendroica petechia*), and eastern kingbirds (*Tyrannus tyrannus*) nest there (Golet and Larson 1974). Such areas are also used extensively by and are important to migrating waterfowl and other marsh and water birds (in the southern United States, this wetland type is one of the most important, as it accomodates many thousands of overwintering waterfowl and other species).

Wet Meadows

This wetland type is seasonally flooded to less than 12 centimeters deep. Reed canary grass, blue joint grass (*Calamagrostis canadensis*), many species of sedges and nutsedges, boneset (*Eupatorium perfoliatum*), and Joe-pye weed (*Eupatorium* sp.) are common components of these communities. Composition of plant species, and therefore wildlife value, is strongly influenced by grazing. A heavily grazed meadow tends to consist almost entirely of soft rush, as cattle will not eat it. Wet meadows are used by several species of passerines for feeding, especially flocks of robins (*Turdus migratorius*), cowbirds (*Molothrus ater*), starlings (*Sturnus vulgaris*), grackles (*Quiscalus quiscala*), blackbirds, and sparrows (Martin *et al*. 1951); red-winged and yellow-headed blackbirds and song and swamp sparrows will nest there.

Shrub Swamp

Permanently flooded areas with shrub stands consisting of buttonbush, red maple, willows, silky dogwood (*Cornus amomum*), gray dogwood (*Cornus racemosa*), red-osier dogwood (*Cornus stolonifera*), highbush blueberry (*Vaccinium corymbosum*), viburnums (*Viburnum* spp.). and sweet-gale (*Myrica gale*) characterize this wetland type. Nesting passerines are the primary users of shrub swamp, but its value varies with the plant species composition and plant community structure.

Wooded Swamp

This wetland type is primarily hardwoods in river and stream floodplains which are seasonally flooded up to 1 meter deep. It also includes wooded areas which are permanently flooded, but these primarily occur in the southern United States and are characterized by bald cypress (*Taxodium distichum*) and Tupelo gum (*Nyssa sylvatica*). The wooded swamps of the north are largely composed of silver maple, swamp white oak, pin oak, green ash (*Fraxinus pennsylvanica*), American elm, eastern cottonwood, willow, and red maple. In the more permanently flooded swamps, red maple is the dominant species. These areas are valuable as breeding habitat for not only wood ducks (*Aix sponsa*) and black ducks (*Anas rubripes*), but for many species of herons, egrets, warblers, flycatchers, woodpeckers, thrushes, nuthatches, vireos, rose-breasted grosbeaks (*Pheucticus ludovicianus*), hawks, owls, grackles, and many passerines (Golet and Larson 1974).

Coniferous wooded swamps have red spruce (*Picea rubens*) and eastern hemlock (*Tsuga canadensis*) in highlands swamp areas, and Atlantic white cedar (*Chamaecyparis thyoides*) in the lowland swamps. These evergreen swamps provide nesting and feeding habitat for golden-crowned kinglets (*Regulus satrapa*), magnolia warblers (*Dendroica magnolia*), red-breasted nuthatches (*Sitta canadensis*), and other warblers (Golet and Larson 1974; Robbins *et al*. 1966).

Acid Bogs

Bogs are formed from deep accumulations of sphagnum moss and usually have very acid pH ranges. This acid, low oxygen environment is not conducive to good wildlife habitat. However, the bogs are used by some ducks for feeding and by warblers, flycatchers, nuthatches, and kinglets for nesting.

Characteristic vegetation of upland bogs included black spruce (*Picea mariana*), tamarack (*Larix laricina*), leatherleaf (*Chamaedaphne calyculata*), sheep laurel (*Kalmia angustifolia*), sweet-gale, and cranberries (*Vaccinium marcocarpon*). Lowland bogs are dominated by Atlantic white cedar with red maple and leatherleaf common.

Salt Marshes

This wetland type occurs in the north only on the Atlantic coast. It included brackish and salt marshes of all categories (deep, shallow, brackish, saline, but are all tidally influenced) occurring on the coast from Maine to Maryland. These salt marshes are dominated by smooth cordgrass (*Spartina alterniflora*) and glasswort (*Salicornia* spp.) in saline areas;

saltmeadow cordgrass (Spartina patens), saltgrass (Distichlis spicata), saltmarsh bulrush (Scirpus robustus), marsh elder (Iva frutescens) and other species in brackish marshes; and with common reed dominating fresh to slightly brackish coastal marshes (Environmental Laboratory 1978; Hunt et al. 1978).

The salt marshes are used extensively for feeding, nesting, and resting habitat by common terns, roseate terns (Sterna dougallii), great black-backed gulls (Larus marinus), herring gulls, laughing gulls (Larus articilla) (in the extreme southern parts of the northeast only), clapper rails (Rallus longirostris), black rails (Laterallus jamaicensis), all herons and egrets except cattle egrets (Bubulcus ibis) in the area, willets (Cataphrophorus semipalmatus) and glossy ibises (Plegadis falcinellus) (Burger 1977a; Robbins et al. 1966; Soots and Landin 1978). Least bittersn (Ixobrychus exilis) also inhabit brackish marshes, as do king rails (Meanley and Wetherbee 1962). Long-billed marsh wrens (Telmadytes palustris), short-billed marsh wrens (Cistothorus platensis), seaside sparrows (Ammospiza maritima), sharp-tailed sparrows (Ammospiza caudacuta) also use salt marshes for nesting, although sharp-tailed sparrows frequently only overwinter in salt marshes (Pettingill 1970; Robbins et al. 1966).

Open Salt Water

Low energy areas that allow growth of aquatics such as eelgrass (Zostera maritima) and wild celery (Vallisneria americana), and marine algae are characteristic of this wetland type. These areas are used extensively by overwintering waterfowl. They are also used heavily by overwintering coots, loons, and grebes. Open estuarine and bay waters are used extensively for feeding by royal terns (Sterna maxima), common terns, roseate terns, Caspian terns (Sterna caspia), least terns (Sterna albifrons), and herring and great black-backed gulls. These species nest on isolated high sites and islands within the wetland area, many of them on dredged material islands (Landin 1978b). The open water areas of this wetland type are generally behind barrier islands, and in bays, coves, and estuaries.

Ideal Wetlands

The ten wetland types are used in varying degrees by non-game and minor game bird species, with wooded swamps and deep and shallow permanent marsh offering the most valuable and diverse habitat. A reasonable generalization is that wetlands increase in value to wetland-using non-game and minor game birds if they:

a. Are located in bottomlands in a fairly large tract of land,
b. Are close to open water and have a stable water supply,
c. Have neutral pH and fertile soil,
d. Offer diversity of vegetation life forms,
e. Are isolated from human populations, and
f. Are free of contaminants.

A wetland is of least value if it is a small upland area with no open water nor permanent water supply, is subject to acidity from decaying vegetation, is in poor soils, has been contaminated from either point or non-point source, and is near urban areas or areas used for recreation. These two extremes of ideal and worst case northern wetlands are of course hypothetical, and most wetlands in the two regions lie between the extremes. The key to increasing non-game bird species use of a wetland lies with developing more of the remaining wetlands of the area into quality habitat and allowing less of it to fall toward the less valuable wetland extreme.

WATER BIRDS

While northern United States wetlands are undoubtedly of immense importance to passerine species, those bird species that will be affected most severely by continued loss or alteration of wetlands are those groups commonly called water birds (herons, egrets, cormorants, ibises, loons, gulls, terns, skimmers, bitterns, grebes, rails, and coots). In the northern states, these species are not abundant with the exception of the ring-billed gull in the Great Lakes and the herring gull on the northeast coast (Soots and Landin 1978).

Declines in populations of great blue herons and common egrets have been noted by Thompson (1977), Thompson and Landin (1978), and Norling (1977). The wading birds in the interior United States are often subjected to contaminated feeding areas (Konermann et al. 1978; Hoffman and Curnow 1977; Keith 1966) although the fish-eating terns and other species seem to encounter less problems from contamination than do the wading marsh feeders. This contamination effect is especially true in the large river systems (Thompson 1977) and the Great Lakes (Hoffman and Curnow 1977). The most frequently encountered problem in the northeast with species such as herons, egrets, terns, and skimmers is human disturbance and a reduction in the quality of their feeding areas (Soots and Landin 1978; Gochfeld 1977; Buckley and Buckley 1976). However, an increase in nesting great blue herons, glossy ibises, Louisiana herons (Hydranassa tricolor), snowy egrets (Leuciphoyx thula), common egrets, cattle egrets, black-crowned night herons (Nycticorax nycticorax) has been noted in the

New England area on offshore islands (Dick Forster, 1979, Massachusetts Audubon Society, personal communication. Forster also reported that common and roseate terns there are declining. Possible causes are similar to problems elsewhere; habitat loss, decline in water quality, and human disturbance.

The least tern is dwindling in numbers on the coasts, and the interior least tern has all but disappeared from its former nesting areas in the Mississippi River and its tributaries (Downing 1975; Hardy 1957). In the rivers, the loss is due to the lack of undisturbed sand bars suitable for nesting (Thompson and Landin 1978), and on the coast it is due almost entirely to lack of bare sand areas and human disturbance and its ramifications (pets roaming through colonies, motorcycle enthusiasts, campers, curious people wanting to "look at the bird eggs and the baby birds", and similar events) (Soots and Landin 1978. The need for bare undisturbed nesting areas is great throughout the least tern's range

Other tern species are either declining in population or are stable, but none are increasing even though Forster's tern has recently extended its range into the Mississippi River (Thompson and Landin 1978). Common terns that have difficulty successfully nesting in the Great Lakes are bothered by night heron, herring gull, and ring-billed gull predation, and lack of suitable nesting habitat. Common terns on the coast have become largely salt marsh nesters (Burger and Lesser 1977) because other suitable isolated sites do not exist (Landin 1978b).

Piping plovers (Charadrius melodus) are small shorebirds that have used upland sand areas and islands in or near Lake Superior wetlands for nesting; their numbers have diminished dramatically in that area because nesting habitat has not remained available to them (Robert Whiting, 1978, U.S. Army Engineer District, St. Paul, personal communication).

Double-crested cormorants (Phalacrocorax auritus) are listed as endangered in Wisconsin (Wallace 1977) and are quite limited in Michigan and other areas of the north central region. The primary cause of their demise has been human persecution and loss of nesting trees, not necessarily loss of wetlands habitat. In a colony of double-crested cormorants in the Upper Mississippi River, a set of nesting boxes have been erected to replace nest trees that have fallen in an old flooded stump field.

The night herons have never been common in the northern states, especially the yellow-crowned night heron (Nyctanassa violacea), and they have decreased in numbers over a period of years with the exception of the New England area, The reasons for this decline are unclear, but it is believed that the cause is contaminated feeding areas (Ohlendorf et al. 1978; Bull 1964).

Bitterns are elusive and an accurate estimate is hard to obtain (Willer 1961), but Wallace (1977) believes that the American bittern (Botaurus lentiginosus) is probably declining in numbers in the Great Lakes area. The least bittern is still common throughout northeast fresh marshes, but it possibly is declining in total numbers also.

Gulls and cattle egrets are the only species that seem to be having little problem adjusting to increasing human populations and decreasing wetland habitats. This is due largely to the fact that cattle egrets are primarily upland feeders, and gulls are scavengers of human garbage which adds large new food sources to their traditional fish/scavenge diet (Soots and Landin 1978; Schrieber and Schrieber 1978).

Ludwig and Tomoff (1966) studies reproductive success in an insecticide residue environment in Lake Michigan, but these residues have had no real effect on the total population in the Great Lakes.

The common loon (Gavia immer) and, less commonly, the red-throated loon (Gavia stellata) are species occurring in the northern states Although botulism die-off has killed large numbers in the past decade (Wallace 1977), populations are still not believed to be in serious trouble. These birds, especially the common loon, overwinters in marine waters, but nests near open water in fresh marshes (Robbins et al. 1966). Martin (1978) has indicated that loons are declining in New England.

PROBLEMS AND CAUSES

Almost all the problems affecting water bird populations and their survival are related to human causes. Increased human populations, especially in the already highly populated northeast and north central states, causes loss or alteration of wetlands due to:

a. Increased recreational use of wetlands (boating, fishing, hunting, bird-watching (Soots and Landin 1978);
b. Drain and fill operations for agricultural and urban use which include mosquito-ditching (Burger 1977b), draining and using former wetlands for agricultural lands (Shaw and Fredine 1956), dredged material fill for marinas and waterfront properties, and other alternatives;
c. Industrial, agricultural, and human wastes in wetlands which

include placement of dredged material from shipping channels on or near wetlands, excessive nutrient loands and pesticides from farming and sewage; and heavy metals and chemicals from industry (Hunt et al. 1978); and

d. Water table and lake level changes from the drawing of fresh water from underground reservoirs for urban use, and the damming, streamlining, or deepening of lakes that cause their level of water to fluctuate.

The wetlands in the nertheast and north central United States have been greatly affected by the above activities. Because wetlands are affected, the bird species that use wetland habitats for any part of their life cycle will decline or increase as a result of changes in those wetlands. Impacts on wetlands have impacted non-game and minor game bird species in several ways. Feeding habitat has decreased or become contaminated, especially in the interior areas (Hoffman and Curnow 1977; Konermann et al. 1978; Thompson 1977; Keith 1966). Nesting site disruption is caused by cutting or clearing vegetation from shrub and wooded swamps, making colony sites accessible to human activities or destroying those colonies, removing the water by draining, and for many other reasons. Resting and loafing sites are affected for the same reasons, except that isolation is not so critical.

All birds are vulnerable while nesting (Pettingill 1970), as they must remain in one location for the duration of the breeding season. Water birds (Herons, egrets, terns, gulls, and others) will nest in large conspicuous colonies and will fly for long distances to reach a desirable feeding area from their nesting site. The herons on West Sister Island in Lake Erie often fly several kilometers to natural and manmade marshes to feed (Soots and Landin 1978).

All birds need differing amounts of seclusion for reproduction to take place (Pettingill 1970). Strongly territorial nesters require this most; i.e., the bald eagle (Haliaeetus leucocephalus) which requires large land expanses around its nest before it will successfully reproduce. Colonial nesting birds, while nesting in dense colonies, still have territorial and nest spacing requirements before they can successfully raise a brood (Soots and Landin 1978; Wiese 1977 and 1978). These birds will tolerate more interference by human colony intruders and observers than non-colonial or solitary nesters (Anderson 1978), but more damage can be done to a given population by entering a colony than in any other way (Soots and Landin 1978).

Solitary nesting birds such as bitterns, rails, and others have a great need of seclusion and thus will tolerate little or no intrusion by humans (Bent 1926; Palmer 1962).

Migratory resting points for not only waterfowl but the numerous non-game and minor game birds which migrate are necessary for many species who stop periodically along their route rather than fly non-stop. Any alternation or destruction of these wetland resting points will have an impact on the number of birds that successfully complete the migration (Scharf 1977).

MANAGEMENT RECOMMENDATIONS

The losses of wetlands over the past 200 years have been tremendous, and the damage is not likely to ever be undone, even in future generations. The wetlands that are now urban and recreational sites, farm lands, and reservoirs will undoubtedly remain as they are now. Pressures are still being placed that put existing wetlands in question, in spite of the Clean Water Act and its Section 404 regulations.

It should be noted that, realistically speaking, a wetlands manager cannot expect to expand the wetlands outside the land he can control, whether it is refuges, game farms, game management areas, or commercial forest operations. In spite of these limitations, even a modest impact by that manager would be of benefit when it was grouped with efforts throughout the region for the benefit of wetlands as wildlife habitat.

Broad Recommendations

There are several obvious recommendations for wetlands that can be made to all wetlands managers and people concerned with the continued existence of wetland areas. First, all the remaining wetlands in the northeast and north central United States should be maintained and enhanced where possible for the benefit of non-game as well as game species. A great deal of emphasis is still placed only on game bird species that use wetlands. Fortunately for the non-game birds, management of areas for waterfowl has helped preserve some habitat for them as well.

Second, the possibility of converting some lands under federal, state, or public ownership back to wetlands from their present status should be investigated, and where it is possible to create quality habitat by this method, it should be done. There are marginal lands in public ownership that could be managed to bring them up to quality habitat by such methods as planting suitable vegetation (Environmental Laboratory 1978); by changing the water level using low-head dams or dikes; and by posting or fencing them to prevent human intrusion (Soots and Landin 1978).

A third broad recommendation is for agencies to continue to do as they have recently begun, and continue to seek and acquire blocks of land from private owners that can be preserved or returned to wetland habitat. These lands are usually under the control of the state conservation agencies, and can be managed to increase their wildlife value. One of the drawbacks in the U. S. Fish and Wildlife Service's acquisition program has been such problems as state agencies not having the funds and the personnel to manage these blocks of land that have come under their control. Another drawback in the same program has been emphasis on mangement for waterfowl only, with not much regard for the non-game birds that would use these areas. In spite of these problems, the program is well worth continuing.

A study that is beginning at the U. S. Army Engineer Waterways Experiment Station which may aid managers in taking marginal poor quality lands and developing and managing them to become higher quality habitat should aid in mitigation efforts of wildlife habitat to be displaced by Corps activities. The research station is also continuing research begun under the auspices of the Dredged Material Research Program (DMRP) on habitat development and management of land areas created from dredged material.

Specific Recommendations

Most specific recommendations can be directed to forest managers who have wetland areas within their control. Close examination of all wetland areas in control and determination of their use and quality could be based on the criteria perviously discussed. If there is quality habitat within an area, it should be maintained and stabilized as it then exists.

Since acid, non-fertile areas are not conducive to wildlife use, these areas could be changed possibly by raising the pH and fertility levels of the wetland, as has been done in areas of the south. This should be approached carefully, however, as this recommendation would also apply to acid bogs, and these areas are often unique. They usually have plant species found in few other places, and any unusual plants should not be disturbed if it is determined that they are in fact rare or endangered.

Building low-head dams or dikes to allow intermittent ponds to become shallow marshes and ponds and to control water levels is another fairly simple way to increase the habitat value. This has already been done in many areas of the northeast and in the southern states (Landin 1978a).

In large open areas where wave action causes erosion problems and prevents much wildlife use, erection of wave barriers or dikes may be necessary to allow marsh formation and to create stillwater areas for feeding birds (Environmental Laboratory 1978). This has been done during the creation of a large new disposal site by the U. S. Army Engineer District, Detroit, in which they deliberately built the disposal dike in an area where a natural marsh would be protected and its eroded parts allowed to rebuild. The area will provide feeding habitat for water birds both behind the site in the existing marsh and inside the dike after it is competed (Richard Gutleber, 1978, U. S. Army Engineer District, Detroit, personal communication). An inovative wave barrier built of floating tire breakwaters in marine areas is being tested in research at the University of Rhode Island.

A fairly inexpensive way to increase the wetland's value is to plant suitable plant species that will be of value to target wildlife species as feeding, resting, and/or nesting habitat (Hunt et al. 1978; Environmental Laboratory 1978). If too many plants are there, as in the case of a thick shrub swamp, shallow marsh, or overgrown bird colony site that has been overtaken by undesirable or an excess of plants, a thinning of these plants to bring back open areas and a diversity in habitat would be of benefit (Soots and Landin 1978).

Precedents for providing nesting areas for birds, such as nesting platforms for ospreys (Pandion haliaetus) in New Jersey and open nesting boxes for cormorants in the Upper Mississippi River (Thompson and Landin 1978), have already been made. In areas of diminishing nesting habitat where birds will not move but slowly decrease in population, this action may be necessary. This may also be the case where an all-out effort to bring back a species, such as the osprey program in New Jersey, needs to be made (Joan Galli, 1976, New Jersey Nongame Biologist, Trenton, personal communication).

One of the most critical needs for nongame bird management is the creation of seclusion and isolation from humans by fencing, posting, law enforcement, or whatever other actions are necessary to insure that colonies and sensitive nesters are undisturbed (Soots and Landin 1978; Buckley and Buckley 1976). Those non-game birds that need this effort most critically are all species of terns, especially the least tern; the herons and egrets of the Great Lakes and interior areas; and the cormorants in the river systems and Great Lakes. These birds are all declining in population. Provision of undisturbed nesting sites which are lacking at the present time for least terns, common terns, roseate terns, and black skimmers (Rynchops nigra) needs to be made. One of the determinations of best use of dredged material by the DMRP has been the placement of fresh dredged material on Corps and other islands for the use of these nesters. The main drawback to this placement has been and probably will continue to be the immediate use by humans of these new sand areas for recreational purposes, especially in the river systems (Richard Baker, 1977, U. S. Army Engineer District, Rock Island, personal communication), which does not give the birds a chance to nest.

Another practice that is recommended and can be implemented by forest managers is leaving vegetation on stream banks, lakesides, and marshes; clearcutting of these areas removes the cover that had been present for many bird species. Numerous passerines nest in the edge of wooded areas adjacent to open water. Wading birds use these areas as cover while hunting for food, and they depend upon the clarity of the water to see their prey. Cutting of streambanks has been shown to greatly increase the muddiness of the water. The recommendation that a 15-20 meter deep fringe to streams, lakes, rivers, and marshes be left would allow critical habitat to remain and protection of the water quality (Russell 1966).

Water levels can be raised or lowered to manipulate vegetation to increase non-game bird habitat. The provision of open water in a marsh area or wooded swamp allows feeding areas for not only waterfowl and the species previously discussed, but allows belted kingfishers (Megaceryle alcyon) and above-water feeding swallows and martins feeding habitat not otherwise provided.

SUMMARY

Wetlands as they existed when this country was settled will never be regained; however, there is much that can be done to not only save that which is left but to enhance its value to wildlife. A continuing and dedicated effort to protect and manage existing wetlands; acquire any new wetland or potential wetland areas for preservation; increase the quality of wildlife habitat, especially for non-game species; and to prevent increasing human populations from intruding into wildlife areas, especially during the critical nesting season, to the detriment of that wildlife must be made by all wetlands and forest managers everwhere. The concern of all persons and responsible agencies is vital to the continuation of the wildlife species which depend upon wetlands for their life requirements. Only when everyone works together will these efforts be successful.

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BIRDS OF UPLAND OPENINGS

Charlotte M. Taylor and William E. Taylor[1/]

Abstract.--Northern forest openings are variable in vegetative life form. Eighty species of nongame birds are associated with forest openings or edge of forest openings in Northern Michigan. Current management is reviewed and suggestions for additional management practices and studies are included.

INTRODUCTION

Upland openings are an integral part of the forest environment. They are the beginning stage in the development of a forest and differ greatly from the usual mental image of a forest represented by trees. Their physical aspect is very different and their biological production - plants and animals - is very different from that of a stand of timber.

Management of forest upland openings is a controversial subject. To the wildlife biologist they represent a unique vegetative association which produces animals not produced in any other vegetative association of the forest. The timber manager looks at upland openings as nonproducing forest lands. This may be a logical consequence since the production of an acre of timber has an identified value while the production of a forest opening is incompletely documented (documented only in terms of a few known game species).

This discussion will review some of the existing information about upland forest openings and attempt to emphasize the value of this vegetative type to nongame birds.

Included are a description of upland openings, a listing of the nongame birds found associated with them, a review of current management, and recommendations for additional management consideration.

Upland openings come in a variety of sizes, shapes, and vegetative forms. All are important when discussing bird communities.

Large upland openings are generally referred to as fields, pastures, abandoned pastures, cultivated areas, grasslands, and/or prairies. Small openings are referred to as forest openings; they may be grassy openings or, if with shrubs and trees, brushy openings.

The importance of upland openings is recognized generally in terms of their importance to game species. McCaffery and Creed (1969) demonstrated the importance of upland forest openings to deer. They consider that "... the principal value of openings to all forms of forest wildlife lies in the variety of vegetation they provide." They acknowledge that "... these values are inadequately known in a quantative sense," but some are at least qualitatively recognized.

Dr. Peterle (1954) and Dr. Amman (1957) documented the necessity of maintaining wildland openings - 640 acres (260 hectares) and larger - if sharptail grouse are to continue as a species in Michigan. Robert Dorney (1959) described the importance of upland openings for ruffed grouse in Wisconsin.

Most studies dealing with nongame birds of upland openings are with large grasslands, cultivated areas, or nonforest types.

Watkins (1895), Frothingham (1900), and Blackwelder (1909) described breeding birds (and others) found in various large open types in Michigan about the turn of the century - about the time of major conversion from forest to farm - and from trees to ashes. More recent work by Kendeigh (1948) in the northern part of the Lower Peninsula of Michigan includes a brief account of breeding birds of a large (100 acre or 40 hectares) meadow.

Breeding bird censuses, American Birds (1973-1978), include studies of fields,

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cultivated areas, and various forest types. Since the minimum size for such studies is twenty-five acres, small forest openings are not included. If clearcutting fits the definition of upland opening, then studies dealing with recently clearcut forest types (Niemi, 1974) provide information about breeding birds in forest openings.

In another study in Minnesota, Barbara Bergstedt and G. Niemi (1974) compared breeding bird populations inhabitating a recent burned and unburned forest. Depending upon the physical structures or life form remaining after the fire, and again depending on the definition of upland opening, the burned forest may be an upland opening.

Dr. Gysel's study of the vegetation and animal use of a powerline right-of-way in Southern Michigan (1962) was one of the first to specifically consider small forest openings and nongame birds. Herman Shugart and D. James (1973) bridged the gap between field and early forest stages in the Study of Ecological Succession of Breeding Bird Populations in Northwestern Arkansas.

It is difficult to make regional interpretations of local bird population studies, or to make local interpretations of regional studies for several reasons. The same bird species may occur in totally different ecological types (deciduous versus conifer type) in different parts of its breeding range, (Kendeigh, 1945). The lack of standardization of type description currently in use makes it difficult at best, and frequently impossible, to interpret or compile summaries (Shugart and James, 1973). This difficulty is compounded by considerable natural variation within the same type. G. Niemi recognized difficulties in measuring changes (comparing populations) of breeding bird populations due in part to lack of homogeneity, or great heterogeneity of habitats, especially where small forest openings are concerned (Niemi, undated). Opening size and the size of the surrounding vegetative type have an important influence on the species component of inhabitating communities (Bond, 1957) but, except for birds like sharptail grouse or upland sandpiper, the relationship is poorly understood.

The description of vegetative types does not always recognize important habitat components. L. Brecker, (1943) recognized life form, "...the physical aspect of the vegetation or the materials in, on, or from which the bird builds its nest, seeks its food and finds its shelter," as a very important factor governing the suitability or availability of the niche. F. James (1971) and H. Shugart and B. Patten (1972) identified and demonstrated life form or vegetative structure as a determinant factor in the selection of niche by birds, yet few if any existing studies use vegetative type descriptions which consider life form in any but the most general way. For instance, a description of a pole size hardwood stand does not include information about understory or ground vegetation.

DESCRIPTION OF UPLAND FOREST OPENINGS

Upland openings are different things to different land managers. To a forester an upland opening is an area with 10% stocking of commercial forest trees and with grass. An opening with 16% or less stocking of seedlings and saplings (less than 5" dbh) is considered as a nonstocked stand. A stand is defined as an area of uniform vegetation composition and structure. Forest biologists generally recognize upland openings as any area without trees. There are grassy openings, grass and forb openings, and shrub openings. The shrubs may be young trees. A nonstocked stand may be considered an opening or it may be considered a sparse stand of trees.

Openings are vegetative stages in the succession pattern of the forest. Their life span - how long they last - depends upon their vegetative composition. In Minnesota the length of time since the last major disturbance and the type of vegetation present at the time of disturbance are important factors in determining the structure and composition of the present plant community (Ohmann, 1973). The formation of dense sod contributes to the lasting qualities of upland openings. Sod openings will last 40-50 years or more if undisturbed. The age of some openings in the northern hardwood types in the Upper Peninsula of Michigan is estimated to be 50 years - Kendeigh found meadows in the northern part of the Lower Peninsula of Michigan changed very little in 29 years (Kendeigh, 1948). Similar situations exist in Minnesota (J. Mathison, 1978).[2]

Sod development in a forest environment results from repeated burns, or intensive burns, cultivation, heavy grazing, or mechanical action which causes soil compaction or herbicide use (J. Wigger, 1978).[3]

Size is a most obvious feature of upland openings and is perhaps one of the more important. Breeding birds found in large openings are different from those associated with small openings: Watkins (1895), Blackwelder (1909), Frothingham (1906), and Kendeigh (1945, 1948). Weather conditions (microclimate) are very different in large and small openings. Forest Stearns and B. Ringger (1972) found that in large openings extremes and duration of extremes of temperature are very different than in smaller openings.

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[2] Mathison, John, 1978, Personal Communication, U.S. Forest Service, U.S. Department of Agriculture.

[3] Wigger, Gerald, 1978, Personal Communication, U.S. Forest Service, U.S. Department of Agriculture.

The distinction between large and small openings is difficult to make. Effective size, in terms of solar radiation, wind movement at ground level, mean and maximum temperature, and relative humidity depend upon the height of the surrounding trees. Dr. Stearns and Ms. Ringger used the ratio of opening diameter to height of surrounding trees to express opening size.

The size in acres of openings of different D/H ratios in different timber types (vegetative types) are indicated in Table 1.

Openings with a D/H ratio of 0.05:1 and smaller are no different than the surrounding forest, in terms of wind movement, solar radiation, radiation out from the opening, and relative humidity. Openings with D/H ratio of 1:1 and D/H 2:1 experience highest average maximum temperature and longest periods of high relative humidity. Wind barely penetrates into them, they have longer frost free periods, and mosquitoes and deer flies are more abundant. Large openings have a D/H ratio of 6:1 or 10:1 or more. Openings with D/H ratio of 10:1 to D/H ratio 20:1 and larger are more appropriately considered grasslands rather than forest openings. (Ringger and Stearns, 1972).

Vegetative composition (species composition) of openings appears less important than the growth form or life form - the overall shapes of the vegetation. Kendeigh (1948) and Bond (1957) recognized that community segregation of birds is correlated with types of vegetation rather than species of plants involved. Kendeigh observed the occurence of some structure: stump, snag, or post, was a suitable substitute for a particular life form plant. Because of its presence birds were invited into areas not normally occupied. S. Ulfstrand (1975) observed that in habitats containing the same number of trees and shrub species, flock diversity of birds will be higher the more structurally diversified the vegetation.

Studies by F. James (1971), H. Shugart and D. James (1973), and J. Niemi (no date), demonstrate the ability to associate bird species with life form rather than species composition.

Upland openings do not exist without edge. Edges have been considered especially productive areas for many species of birds. Studies in mixed forest type borders (edges) by Marten (1960) in Ontario, documented large populations of birds - more species were present there than were found in the interior forest. Egler (1966) considered the edge between forest and upland opening (right-of-way) to be valuable habitat for nongame birds. Gates and Gysel (1978) working in a continuous field-forest edge found that with increasing distance from the edge, changes in habitat composition and structure apparently resulted in decreasing numbers of nests of the open-nesting passerines found during their study. They also found that over half of the nests were found within 15 meters (approximately 50 feet) of the edge. Seventy-five percent of the nests belonged to birds characteristic of mixed breeding habitat, i.e., birds requiring an open vegetative canopy with dense cover near the ground for nesting and feeding, and elevated singing and observation perches.

Carlson (1976) found in an opening-jack pine mixture in Northern Michigan that all successful nests of bluebirds were in habitat that contained both open areas with scattered trees and densely stocked areas.

Although the importance of "edge" for a diversity of species has been emphasized by a number of authors, Gates and Gysel (1978) have issued a warning about the dangers inherent in narrow edge situations and question their value. They do not dispute the importance of edge; indeed in their study at Rose Lake they found most nests there, but nesting success was greatly reduced. They cited predation and cowbird parasitism as the most important reasons for failures, and believe the increased predation rate was a response to the concentration of nests. They propose that narrow man-made forest edges could well function as "ecological traps" for avian species characteristic of habitats with mixed life form. Because they say extensive areas of narrow field-forest edge have only been in existence for a brief period relative to the evolutionary time scale, these may then not be like the ecological niche in which these mixed habitat species developed and so they may not be able to cope with the increased predation. The most important aspects of upland openings are vegetative life form and size.

BIRDS OF UPLAND OPENINGS

The preparation or interpretation of a list of birds of upland openings must be done with considerable reservation. R. Bond (1957) and S.C. Kendeigh (1945, 1948) both indicate that bird populations are not really divisible

Table 1.--Acres - Size of Opening by D/H and Tree Height.

D/H Ratio	White Pine 85'	Maple 80'	Red Pine 70'	Aspen 65'	Spruce Fir 50'	Jack Pine 50'
1:1	.52	.46	.35	0.30	0.18	
2:1	2.08	1.85	1.41	1.22	.72	
3:1	4.69	4.15	3.18	2.75	1.62	
4:1	8.34	7.39	5.65	4.88	2.88	
5:1	13.01	11.54	8.83	7.62	4.51	
6:1	18.76	16.62	12.72	10.97	6.49	
7:1	25.53	22.62	17.32	14.93	8.83	
8:1	33.35	29.54	22.62	19.50	11.54	
9:1	42.21	37.39	28.62	24.68	14.60	
10:1	52.11	46.16	35.34	30.47	18.03	
20:1	208.43	184.63	141.36	121.88	72.12	
30:1	468.97	415.42	318.05	274.24	162.27	
40:1	833.72	738.52	565.41	487.54	288.48	
50:1	1302.69	1153.94	883.48	761.78	450.76	
60:1	1875.87	1661.67	1272.22	1096.96	649.09	
70:1	2553.27	2261.72	1731.63	1493.09	883.48	
80:1	3334.88	2954.08	2261.72	1950.15	1153.94	
90:1	4220.70	3738.75	2862.48	2468.16	1460.45	
100:1	5210.75	4615.75	3533.93	3047.11	1803.03	

Table 1 A.--Hectares - Size of Opening by D/H Ratio and Tree Height.

D/H Ratio	White Pine 85'	Maple 80'	Red Pine 70'	Aspen 65'	Spruce Fir 50'	Jack Pine 50'
1:1	.21	.19	.14	.12	.07	
2:1	.84	.75	.57	.49	.29	
3:1	1.90	1.68	1.29	1.11	.66	
4:1	3.38	2.99	2.29	1.97	1.17	
5:1	5.27	4.67	3.57	3.08	1.83	
6:1	7.59	6.73	5.15	4.48	2.63	
7:1	10.33	9.15	7.01	6.04	3.57	
8:1	13.50	11.95	9.15	7.89	4.67	
9:1	17.09	15.13	11.58	9.99	5.91	
10:1	21.09	18.68	14.30	12.33	7.30	
20:1	84.35	74.72	57.21	49.32	29.19	
30:1	189.79	168.12	128.71	110.98	65.67	
40:1	337.40	298.87	228.82	197.30	116.75	
50:1	527.19	466.99	357.54	308.29	182.42	
60:1	759.15	672.47	514.86	443.93	262.68	
70:1	1033.29	915.31	700.78	604.25	357.54	
80:1	1349.61	1195.50	915.31	789.21	446.99	
90:1	1708.09	1513.05	1158.43	998.85	591.04	
100:1	2108.76	1867.97	1430.16	1233.15	729.68	

Table 2.--Birds of Upland Openings

	Large Opening	Small Opening	Edge	Forest
Turkey Vulture(*Cathartes Aura*)	—	—	—	—
Sharp Shinned Hawk(*Accipter striatus velox*)		—	—	—
Red Tailed Hawk(*Buteo jamaicensis*)	—	—	—	
Broad-winged Hawk(*Buteo platypterus*)			—	—
Rough-Legged Hawk(*Buteo lagopus*)	—			
Marsh Hawk(*Circus cyancus*)	—	—		
Kestrel(Sparrow Hawk)(*Falco sparverius*)	—	—	—	
Sandhill Crane(*Grus canadensis*)	—	—	—	—
Killdeer(*Charadrius vociferus*)	—			
Upland Sandpiper(*Bartramia longicauda*)	—			
Herring Gull(*Larus argentatus*)	—			
Ring Billed Gull(*Larus delawarensis*)	—			
Mourning Dove(*Zenaidra macroura*)	—	—	—	
Snowy Owl(*Nyctea scandiaca*)	—	—		
Hawk Owl(*Surnia ulula*)		—	—	
Short-eared Owl(*Asio flammeus*)	—	—		
Whip-poor-Will(*Caprimulgus vociferus*)		—	—	—
Night Hawk(*Chordeilis minor*)	—	—	—	—
Chimney Swift(*Choetura pelagica*)	—	—	—	—
Ruby throated Hummingbird(*Archilochus colubris*)		—	—	
Flicker(*Colaptes auratus*)	—	—	—	—
Downy Woodpecker(*Dendrocopus pubescens*)		—	—	—
Eastern Kingbird(*Tyrannus tyrannus*)	—	—	—	
Phoebe(*Sayornis phoebe*)	—	—	—	
Least Flycatcher(*Empidonax minimus*)		—	—	—
Horned Lark(*Eremuphilia alpestris*)	—			
Tree Swallow(*Iridoprocne bicolor*)	—	—		
Bank Swallow(*Riparia riparia*)	—	—	—	—
Rough-winged Swallow(*Stelgidopteryx ruficollis*)	—	—	—	—
Barn Swallow(*Hirundo rustica*)	—	—	—	
Cliff Swallow(*Petrocheliden pyrrhonota*)	—	—	—	
Purple Martin(*Progne subis*)	—	—	—	
Bluejay(*Cyanocitta cristata*)	—	—	—	—
Raven(*Corvus corax*)	—	—	—	—
Crow(*Corvus brachyrhynchos*)	—	—	—	—
Black Capped Chickadee(*Parus atricapillus*)		—	—	—
House Wren(*Troglodytes aedon*)		—	—	
Catbird(*Dumatella carotinensis*)		—	—	
Brown Thrasher(*Toxostoma rufum*)		—	—	
Robin(*Turdus migratorius*)	—	—	—	—
Eastern Bluebird(*Sialis sialis*)	—	—	—	
American Pipit(*Anthus spinoletta*)	—			
Cedar Waxwing(*Bombycilla cedrorum*)	—	—	—	
Northern Shrike(*Lanius excubitor*)	—	—	—	
Loggerhead Shrike(*Lanius ludovicians*)	—	—	—	
Starling(*Sturnus vulgaris*)	—	—	—	—
Black & White Warbler(*Mniotilta varia*)		—	—	—
Nashville Warbler(*Vermivora ruficapilla*)		—	—	
Yellow Warbler(*Dendroica petechia*)		—	—	
Yellow-rumped Warbler(*Dendroica coronata*)		—	—	—
Chestnut-sided Warbler(*Dendroica pensylvanica*)		—	—	
Mourning Warbler(*Oporornis philadelphia*)		—	—	
Northern Yellowthroat(*Geothlypis trichas*)		—	—	
Bobolink(*Dolichonyx oryzivorus*)	—			
Eastern Meadowlark(*Sturnella magna*)	—			
Western Meadowlark(*Sturnella neglecta*)	—			
Red-wing(*Aqelaius phoeniceus*)	—	—		
Rusty Blacbird(*Euphagus carolinus*)	—	—		
Brewer's Blackbird(*Euphagus cyanocephalus*)	—			

Table.--continued

	Large Opening	Small Opening	Edge	Forest
Common Grackle(*Quiscalus quiscula*)	—	—	—	
Cowbird(*Molothrus ater*)	—	—	—	—
Indigo Bunting(*Passerina cyanea*)		—	—	
Purple Finch(*Cardo purpureus*)		—	—	—
Pine Grosbeak(*Pinicola enucleator*)		—	—	—
Redpoll(*Acanthus flammea*)	—	—	—	
Pine Siskin(*Spinus pinus*)	—	—	—	
American Goldfinch(*Spinus tristis*)	—	—	—	
Rufous-sided Towhee(*Pipilo erythropthalmus*)		—	—	
Savannah Sparrow(*Passerculus sandwichensis*)	—			
Grasshopper Sparrow(*Ammodramus savannarum*)	—			
Vesper Sparrow(*Pooecetes gramineus*)	—			
Dark Eyed Junco(*Junco hyemalis*)		—	—	—
Tree Sparrow(*Spizella arborea*)		—	—	
Chipping Sparrow(*Spizella passerina*)		—	—	
Clay Colored Sparrow(*Spizella pollida*)		—	—	
Field Sparrow(*Spizella pusilla*)	—	—	—	
White-throated Sparrows(*Zonotrichia albicollis*)		—	—	—
Song Sparrow(*Melospiza melodia*)	—	—	—	
Lapland Lonspur(*Calcarius lapponicus*)	—			
Snow Bunting(*Plectrophenax nivalis*)	—			

into groups corresponding to any plant association, but that "groups' readily overlap one another. F. James (1971), H. Shugart, and D. James (1973), using modern statistical methods have been able to locate birds along a continuum of vegetational structure from open country to forest association in Arkansas. Bergstedt and Niemi (1974) have undertaken a similar study in a burned over forest area in Minnesota.

Unfortunately there are no known similar studies of upland openings in the northern Lake States. The list of birds of upland openings (Table 2) is based on the observations of many persons (Taylor)[4/] in addition to published accounts.

The distinction between birds of small openings and edge is poorly documented.

UPLAND OPENING MANAGEMENT

Nature provides upland openings, grassy and shrubby, through such agents as fire, wind, flooding (including beaver flooding), insects, disease, and the death of old trees.

Modern forest management discriminates against these openings in several ways. Forest fires are prevented or controlled. Modern silviculture works to minimize loss of wood through old age, insects and disease. Timber harvest methods are scheduled to achieve immediate reestablishment of forest stands. Tree plantings are used where delay in reestablishment is experienced or expected, and to fill in nonstocked or partially stocked stands.

If openings are to remain a part of the forest, the need for them must be recognized, and their development, maintenance, and protection planned.

In the Lake States, upland opening management has been, and largely is, based on the recognized needs of game species. Large upland openings - 200 acres (80 hectares) and larger - are a special management situation to benefit sharptail grouse or geese.

Small forest openings are managed as a part of the forest. The objective usually is to maintain a percent of forest lands in the upland openings. The percent, from 1-5%, is based on a compromise with other management activities - often to favor a target species such as ruffed grouse, deer, kirtland's warbler, or sandhill crane.

The size of the openings vary from 1/2 (0.2 hectares) to 10 (4 hectares) acres; most are about 1 acre (0.4 hectares). Size may be based on a requirement for a particular species (as noted above), on tradition, opinion, or simply to complement other forest management activities.

Distribution of upland openings is usually planned to take advantage of an existing opening or situation which will require the least development costs, and to attain uniform distribution.

Management procedure is to maintain existing suitable openings and develop additional openings as needed. Methods used include timber harvest, hand cutting trees and shrubs, prescribed burning, use of herbicides and mechanical methods such as bulldozer and roller chopper. In the future livestock grazing may become important as a maintenance and development tool in the special management of large opening. With all treatment the objectives are to kill all woody vegetation and establish or reinforce the sod ground cover. Use of herbicide provides the best and most certain result.

UPLAND OPENING MANAGEMENT RECOMMENDATION

AND RESEARCH NEEDS

In the absence of biological information about optimum size - forest type relationships, it is prudent to vary opening size (D;H ratio). Size variation (D/H ratio of 1:1 to about a D/H ratio of 20:1) will compensate for our lack of knowledge of the habitat requirement of the majority of animals of opening and edge, and minimize any trend to create monotype openings.

The variety of types of openings is as important as the size or number. Different arrangements of the vegetative life forms prove attractive to different species. The difference between an opening with bluebirds, flickers, or kestrels may be only the absence or presence of a snag or two.

Kingbirds may use stumps, firecharred (Pinkowski, 1977) or not (personal observation) for nesting. A clump of shrubbery may harbor nesting and feeding birds that would not otherwise be there. In their discussion of park-like areas, Hooper et al (1973) found that some plots had greater bird diversity than they expected, and they believed that clumped vegetation provided nesting and escape cover for more birds than could have been supported if this small amount of vegetation had been dispersed.

[4/] Taylor, Charlotte M., 1966-1978, Breeding Bird Surveys on Two Routes in Michigan's Upper Peninsula, (Unpublished).

In various bird studies emphasis generally has been on breeding birds; use by birds for other than breeding may well be overlooked - as examples, all the broad-winged hawk nests that Carlson (1976) found in his study areas were within 425' (130 meters) of a forest opening and most of them were much closer. Sandhill cranes nest in bogs, but do their feeding and bring their young to feed in the forest openings. Aerial feeding birds, such as nighthawks, are frequently seen over openings. The scavengers, crows, ravens, and vultures patrol the openings. Robins come for blueberries and short-eared owls for their food. Migrating finches feed on the forbs and shrubs. In considering the numbers and kinds of openings, all these uses should be recognized.

Openings should be planned to furnish particular life forms. To this end our present concern for seeding openings, or favoring various grass, grass-forb, or shrub associations needs to be expanded to provide other life form aspects, such as stumps, snags, hollow logs, fallen trees or standing trees.

Life forms of the forest not available elsewhere in the forest, such as sparse stands or park-like stands, should be provided as a part of upland opening management.

The description, or interpretation of life form is more basic to the understanding and management of nongame birds (and game birds), than are timber types or currently used forest vegetation designations. Development of procedures to interpret life form from type designation is desirable. The availability to interpret a vast amount of timber management data in terms of biomass of the various parts of a forest stand would be a giant step toward description of life form, with a minimum of additional effort. James (1971), Anderson and Shugart (1974), and Shugart and Patten (1972) have developed methods that could be utilized.

Livestock grazing has been mentioned as a tool. It may also become a reason for openings - this is still new so the effects it may have are speculative.

The partial list of the birds using these openings should be completed before grazing starts so that the effect of grazing on the birdlife can be assessed.

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EFFECT OF FOREST FRAGMENTATION ON BIRD POPULATIONS

Chandler S. Robbins [1]

Abstract.--Many of the insectivorous songbird species that winter in the tropics are dependent on large unbroken tracts of forest during the breeding season. These species are disappearing from localities where forests are becoming fragmented. By long-range planning, managers can prevent local extinctions of these area-sensitive birds through use of such techniques as management in large units, retention of connecting corridors, and prevention of excessive isolation of forest fragments. Edge conditions can be provided, where appropriate to meet the needs of upland game species.

INTRODUCTION

Birds are sensitive indicators of habitat conditions, because each bird species has its own distinctive breeding range and habitat requirements. Habitats can be managed to increase or decrease abundance of bird species, with information derived from correlating bird populations with quantitative descriptions of the habitats in which they nest. Likewise, the presence or even abundance of certain species can be predicted on the basis of geographical location and habitat descriptions (Robbins 1978).

The purpose of this presentation is to discuss a relatively new concept in forest management: the dependence of many of the neotropical migrants on extensive tracts of forest. Just as many species of birds are restricted to certain types of habitats (woodland, prairie, desert, tundra), some species are adapted to living in the interior of an extensive forest while others utilize habitat boundaries such as wood margins and hedgerows. Each species has evolved over thousands of years and its populations have reached a state of equilibrium within its particular preferred environment. When habitat conditions change as a result of plant succession, climatic changes, or various influences brought about directly or indirectly by man, the survival potential of the species changes. When these changes favor a species, the population may spread into the favorable habitats and increase in size. When altered habitat conditions result in increased mortality or lowered reproductive rate, the population will decline unless it can be supported by immigration from nearby areas where a high reproductive rate produces a surplus of individuals. If a supply of invading individuals is not available or is insufficient to make up for the deficit, the population may decrease to a new lower equilibrium or even disappear entirely from the region of altered habitat.

I first present the results of some recent studies relating changes in breeding bird populations to changes taking place in the environment. Following that I suggest some guidelines for management of forests to benefit those nongame bird species that are disappearing as a result of failure to take their needs into consideration.

AREA SENSITIVITY

In the eastern and north central forest regions of the United States, there are many species of birds that are dependent on extensive forest systems. In recent decades these species have been retreating in the face of fragmentation of forest by such impacts as suburban sprawl, super highways, transmission lines, reservoirs, and surface mining. These sensitive birds have all but disappeared from suburban and highly agricultural areas.

Bird students have been aware of the sharp decline in breeding populations of flycatchers , vireos, warblers, and other long-distance migrants in woodland in and near the

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District of Columbia (Criswell et al. 1978). These decreases have been attributed by various investigators to a variety of causes, including sewer and highway construction, predation, greater human use, storm damage, pesticides, and loss of habitat in the vicinity of the study plots and on the wintering grounds.

Ornithologists in both Europe and America have shown that more bird species can be found nesting in large study plots than in small ones (Oelke 1966, Moore and Hooper 1975). This conclusion seems obvious, because birds are patchily distributed in most habitats, which in itself is because most habitats are structurally heterogeneous. A major reason for increased avian diversity in larger tracts, however, was overlooked by these authors.

Bond (1957), who studied bird populations in woodlots in southern Wisconsin, was the first to report that many species of small songbirds are dependent on relatively large forest tracts during the breeding season. MacArthur and Wilson (1963, 1967) demonstrated the relation between oceanic island avifaunas and the size and degree of isolation of the islands. They also suggested that the same equilibrium between colonizations and extinctions might exist on fragmented woodlots. In oceanic or mainland models, the number of breeding species increases with "island" size and decreases with distance from sources of repopulation. Whitcomb (1977) has summarized MacArthur and Wilson's widely accepted equilibrium theory of island biogeography, and discussed its implications for biotic diversity. He pointed out that: (1) as many as 92 percent of the breeding birds in some forests are migratory, (2) most of these are area-sensitive species that cannot persist in the face of forest fragmentation, and (3) they are not replaced by other species.

New Jersey Studies

In 1972 Galli et al. (1976) and Forman et al. (1976) studied bird populations on 30 forest fragments in central New Jersey. They used analysis of variance to detect those species dependent on the size of the forest fragment. Their forests varied in size from 0.01 to 24 ha. Unfortunately they did not present comparable data from a large area of continuous forest for comparison with their forest fragments. Furthermore, only one of their fragments was greater than 10 ha in size. Although they concluded that half of the forest species using their study plots were dependent on forest area, those species that are most critically dependent on area were lacking from all of their plots and consequently were not recognized as being area dependent.

Sources of Maryland Data

During the breeding seasons of 1974-76, R. F. Whitcomb and colleagues undertook a more extensive study of area sensitivity of eastern deciduous forest birds (Whitcomb et al., 1979). Realizing the urgency of obtaining a broad base of bird population data from forested plots of many sizes and degrees of isolation, they used four techniques. Breeding Bird Census (Williams 1936) and Point Survey data (Whitcomb et al., 1979) from 30 forest fragments ranging in size from 1 to 121 hectares were supplemented with data obtained from the results of Breeding Bird Survey Miniroutes (Bystrak 1978) and a Breeding Bird Atlas project (Klimkiewicz and Solem 1978). They used bird counts from 185 Miniroute stops scattered throughout Howard County, Maryland, and 700 stops throughout Prince Georges County; each of these Miniroute points was covered twice. The Atlas data, gathered by members of the Maryland Ornithological Society, showed which species were detected in each of the 25 square kilometer blocks throughout Montgomery County and 6.25 square kilometer blocks throughout Howard County.

Characteristics of Area-sensitive Species

Whitcomb et al. (1979) computed an index of area sensitivity for each forest bird species by dividing the average number of territories detected at sampling points within small (6-14 ha) forest islands by the number detected in large (80+ ha) forest tracts. They noted strong correlations between the area sensitivity of many bird species and their regional distribution and abundance in forest habitats. When they compared area sensitivity of each forest bird species with characteristics of its breeding biology, they found that most of the species sharply reduced by forest fragmentation have the following characteristics: (1) they are long-distance migrants that winter primarily in the New World tropics; (2) they are obligate inhabitants of forest interior; (3) they tend to nest on or near the ground; (4) they build nests in the open rather than in the protection of cavities; (5) they raise only a single brood of young per year; and (6) they have a comparatively small clutch size.

In contrast, many bird species that reproduce successfully under forest edge conditions are permanent residents or short-distance migrants that arrive early in the season and attempt two or more broods per season. The average nest height of these species is greater, more of them nest in cavities, and they raise many more young per year. Because of a higher reproductive potential, edge-inhabiting bird species have a much greater chance of reproductive success in areas where predation from mammals, jays, and grackles is higher, nest parasitism from cowbirds is more frequent, and disturbance from humans is higher. On the other hand, some neotropical migrants that specialize in edge or scrub habitat (e.g., Prairie Warbler, Orchard Oriole, Blue Grosbeak) show some of the same tendencies for lower reproductive effort and higher sensitivity.

Area Sensitive Species

The area-sensitive forest interior species recognized by Whitcomb et al. (1979) include not only the Yellow-billed Cuckoo, Wood Thrush, Red-eyed Vireo, Black-and-white Warbler and Scarlet Tanager recognized by Galli _et_ _al_. (1976), but also the Whip-poor-will, Pileated Woodpecker, Acadian Flycatcher, Veery, Yellow-throated Vireo, Worm-eating Warbler, Northern Parula Warbler, Ovenbird, Louisiana Waterthrush, Kentucky Warbler, Hooded Warbler, and American Redstart, as well as such wide-ranging species as hawks and owls.

Effects of Forest Fragmentation

A few specific examples will emphasize the dependence of area-sensitive species on large tracts of undisturbed forest interior, tracts greatly in excess of the 1-5 ha territory size actually defended by most small migratory nongame birds during the breeding season. The following examples are based on 3 long-term studies in which I have been involved, and 3 long-term Breeding Bird Censuses published in _American Birds_.

Laurel

In 1952, I moved into my present home beside the Patuxent River gorge on the outskirts of Laurel in central Maryland. At that time the forest along the river was interrupted 3/4 km below me by the City of Laurel, but continued essentially unbroken for 14 km upstream (fig. 1a). The contiguous forest totaled about 5260 ha at that time, but it became progressively more fragmented during the ensuing 25 years. First, Rocky Gorge Reservoir was created 3/4 km upstream from my home; next, Interstate 95 was constructed between my home and the reservoir; and then the hillside directly across the river was cleared of trees (fig. 1b).

Although my woods and the remaining contiguous area of forest totaling about 40 ha have not changed appreciably in character, half of the long-distance migrants that nested here 25 years ago have disappeared: Broad-winged Hawk, Whip-poor-will, Yellow-throated Vireo, Black-and-white Warbler, Worm-eating Warbler, Ovenbird, Louisiana Waterthrush, Kentucky Warbler, and Hooded Warbler (table 1). The Acadian Flycatcher, Eastern Wood Pewee, Wood Thrush, Red-eyed Vireo, Northern Parula Warbler, and Scarlet Tanager still nest here nearly every year, but in reduced numbers; and one pair of Red-shouldered Hawks still remains--perhaps

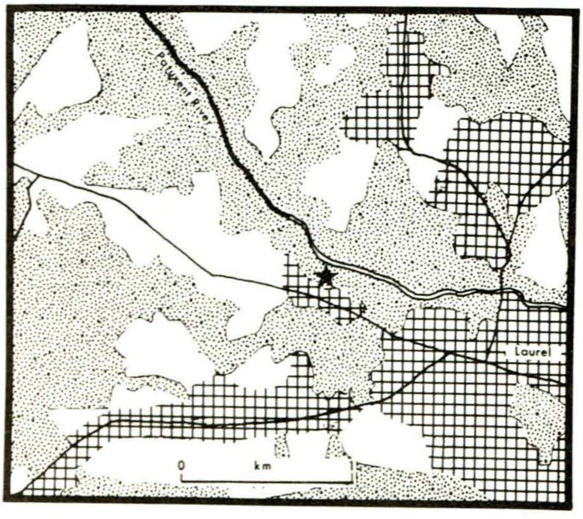

Figure 1a.--Vicinity of Laurel, Maryland, showing forest cover (dots), fields (white), urban areas (small squares), and main highways (black lines) as indicated in 1951. Woods referred to in the text are marked with a star. (USGS 7.5-min. Laurel, Md., quadrangle, 1951)

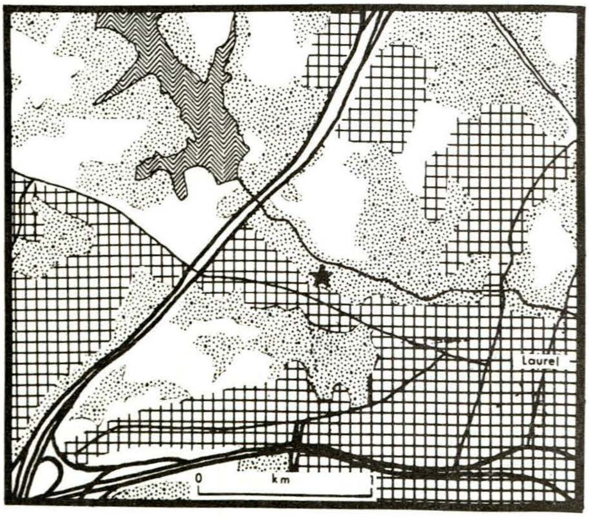

Figure 1b.--Same area in 1971, showing Rocky Gorge Reservoir, Interstate Route 95, Maryland Route 198 (bottom), and severe fragmentation of woodland. (USGS 7.5-min. topographic map, 1965, photorevised 1971)

Table 1. Population changes of long-distance migrants

Site	Laurel		Cabin John		Rock Creek		Glover-Archbold		Seton Belt		Patuxent WRC	
Plot size (acres)	--		18.75		80	65	35		36		90	135
Forest area (acres)	13,000	100	200	75	850		185		39		7400	
Years	1953-54	1977-78	1947-48	1976-77	1948-49	1974-77	1959-60	1976-77	1947	1975-76	1959	1972
Broad-winged Hawk	X[1]	0										
Yellow-billed Cuckoo	X	X	5.0	0	1.0	0			3.0	1.5	0	3.0
Whip-poor-will	X	0										
Ruby-throated Hummingbird	X	X	5.0	0	3.0	0			4.0	+[2]	2.0	1.5
Great Crested Flycatcher	X	X	14.5	5.0	4.5	+	14.0	0	8.0	0	0	0.5
Acadian Flycatcher	X	X	34.5	34.5	27.0	1.0	25.5	3.0	33.0	18.1	25.0	14.5
Eastern Wood Pewee	X	X	26.5	8.0	7.0	2.0	8.5	1.0	19.0	20.1	4.0	0.5
Wood Thrush	X	X	21.5	0	20.0	8.5	32.0	4.5	40.0	81.9	20.5	14.0
Veery					0	5.5	40.0	57.5			0	+
Yellow-throated Vireo	X	0	9.5	0	8.0	0	3.5	0	19.0	2.1	2.0	3.5
Red-eyed Vireo	X	X	74.5	40.0	52.0	18.5	31.5	12.5	100.0	92.4	50.0	50.5
Black-and-white Warbler	X	0	V[3]	0	3.5	0			11.0	0	3.5	0
Worm-eating Warbler	X	0	V	0					3.0	0		
Northern Parula Warbler	X	X	70.5	8.0	0.5	0	11.5	0	4.0	+	3.5	2.0
Ovenbird	X	0			49.0	12.0	8.5	2.0	53.0	22.9	14.5	8.5
Louisiana Waterthrush	X	0	5.0	0	0	0.5	+	0			4.5	2.0
Kentucky Warbler	X	0	28.0	0	1.0	0	8.5	0	17.0	9.7	11.0	5.0
Hooded Warbler	X	0	11.0	0	5.0	0	15.0	0	8.0	1.4	19.0	0.5
American Redstart			68.0	13.5			34.0	+			9.0	7.0
Scarlet Tanager	X	X	13.5	0	9.0	6.5	8.5	0	26.0	12.5	15.5	7.5
Mean species per year	-	-	31.0	21.5	26.5	21.5	42.0	26.5	28.0	25.5	32.0	47.0
Percent change in species	-50%		-31%		-19%		-37%		- 9%		+47%	
Mean pairs/100 acres	-	-	658.5	364.0	223.1	126.9	718.6	453.6	437.0	390.3	289.4	260.5
Change in total population	-		-45%		-43%		-37%		-11%		-10%	
Pairs of long-distance migrants/100 acres	-	-	387.0	109.0	190.5	54.5	232.5	80.5	348.0	262.6	184.0	120.5
Change in long-distance migrants	-		-72%		-71%		-65%		-25%		-35%	

[1] X = Present, but density not determined
[2] + = Present in very small numbers, less than one-half territory
[3] V = Visitor, not nesting in study plot

receiving recruitment from the thriving population on the Patuxent Wildlife Research Center 8 km downstream.

Cabin John Island

A second example of a drastic change in bird population is evident on Cabin John Island in the Potomac River 4 km northwest of Washington, D. C., where breeding bird populations have been studied almost annually since 1947. This island is more than 500 m long and has an average width of 150 m (fig. 2a). Although vegetation of the island itself has not changed appreciably during the study period, there has been significant road construction, particularly the George Washington Memorial Parkway on both sides of the river, that has fragmented the formerly continuous forest that flanked both shores (fig. 2b). Many of the other nearby forests have yielded to housing developments.

During the 30-year study, five species that had originally been represented by two or more breeding pairs disappeared completely. These were the Wood Thrush, Yellow-throated Vireo, Kentucky Warbler, Hooded Warbler, and Scarlet Tanager. Three other less common species, the Yellow-billed Cuckoo, Ruby-throated Hummingbird, and Louisiana Waterthrush, also disappeared (table 1). Several other species declined 46% or more: Great Crested Flycatcher, Eastern Wood Pewee, White-breasted Nuthatch, Red-eyed Vireo, Northern Parula Warbler, and American Redstart (Thatcher 1948, Criswell and Gauthey 1977, and Criswell et al. 1948). The only neotropical

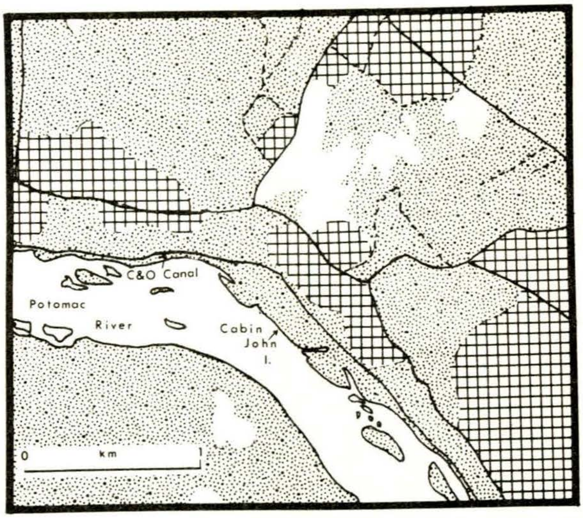

Figure 2a.--Vicinity of Cabin John Island as shown in 1951. (USGS 7.5-min. Falls Church, Va.-Md. quadrangle, 1951) Shading as in figure 1.

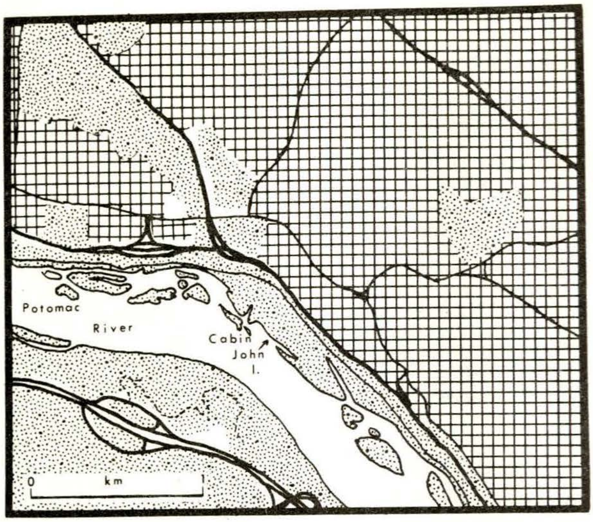

Figure 2b.--Same area in 1971, showing urban expansion and fragmentation of forest by major highways. (USGS 7.5-min. Falls Church, Va.-Md. quadrangle, 1965, photo-revised 1971)

migrant that did not decrease from 1947-48 to 1976-77 was the Acadian Flycatcher.

Rock Creek Park

Two similar long-term studies have been conducted in Rock Creek and Glover-Archbold parks, major wooded areas within the District of Columbia. Rock Creek Park is a long, narrow area of about 800 ha along Rock Creek. It is completely surrounded by city and for many years has not been connected to the narrow strip of forest along the Potomac River by even a wooded corridor. Near the center of Rock Creek Park is a 26 ha study plot in which breeding birds have been censused intermittently since 1947. The original study plot (32 ha) was part of a 345 ha tract bordered on the north by Military Road and on the south by Porter Street. Beach Drive, Glover Road, Tilden Street, and several minor roads traverse the 345 ha wooded tract, but the total amount of contiguous woodland present has changed very little during the 30-year period of the study. Automobile traffic and pedestrian use has increased in both the study plot and the Park in general. Comparing (table 1) the early studies of Thatcher (1949) with more recent studies by Craven et al. (1974) and Criswell _et al_. (1978) one notes that the Yellow-billed Cuckoo, Ruby-throated Hummingbird, Yellow-throated Vireo, Northern Parula Warbler, Kentucky Warbler, and Hooded Warbler no longer breed in the study plot. Other species that have decreased by more than 50% during this period are the Great Crested Flycatcher, Acadian Flycatcher, Eastern Wood Pewee, Wood Thrush, Red-eyed Vireo, and Ovenbird. Recent surveys indicate that changes in bird population recorded within the plot are characteristic of the entire Rock Creek Park forest system.

Glover-Archbold Park

Glover-Archbold Park and adjacent wooded areas make up about 75 ha of woodland that are connected by a narrow corridor to the fringe of woods along the Potomac River. Breeding birds in the park have been censused annually since 1959 (Briggs 1960, 1961, 1977, 1978). Except for the results of sewer construction in 1963, there has been no major change in the habitat of the study plot.

Neotropical migrants that were found nesting on the 14 ha study plot in 1959 or 1960 but were absent in 1976 and 1977 were Broad-winged Hawk, Great Crested Flycatcher, Yellow-throated Vireo, Northern Parula Warbler, Kentucky Warbler, Hooded Warbler, and Scarlet Tanager. The following additional species decreased more than 60% during the same period: Acadian Flycatcher, Eastern Wood Pewee, Wood Thrush, Red-eyed Vireo, Ovenbird, and American Redstart.

Seton Belt Mature Woodlot

In 1947, Stewart and Robbins (1947) censused the breeding bird population in a 15 ha plot within a fine stand of about 16 ha of mature tulip-tree--oak forest in southern Prince Georges County, Maryland. The results showed an exceptionally high density of breeding birds, 1,080 territorial males per square km. It is believed to be the largest remnant of nearly virgin forest on the coastal plain of Maryland.

Whitcomb et al. (1977) censused this woodlot again in 1975 and 1976 using the same boundaries and techniques as in 1947. Their report includes a map showing the location of this South Tract plot with relation to highways and nearby woods. The changes in density of neotropical migrants are much less than in the other plots studied (table 1).

Patuxent Wildlife Research Center

In 1959, I censused the breeding bird population in an undisturbed 36 ha portion of the mature deciduous forest along the Patuxent River in Prince Georges County, Maryland. The census plot was a mosaic of well drained and poorly drained floodplain with small islands of the neighboring river terrace, into which one-third of the plot projected. This plot, by virtue of its size, lack of disturbance, habitat diversity, and location within a 3000 ha forest on the Patuxent Wildlife Research Center and adjacent Fort George G. Meade, contained the entire avian species pool of the eastern deciduous forest of coastal plain Maryland. Breeding populations of the neotropical migrants are listed in table 1; for populations of the other species see Stamm et al. (1960). The bird population was subsequently sampled annually by 12 days of mist netting each summer through 1972, and breeding bird censuses were repeated every few years.

Timber was not cut in or near the study plot; however, all of the following disturbances probably contributed to the change in avian populations shown in table 1: (1) One corner of the plot was permanently flooded by construction of a duck pond in a nearby field; in addition to loss of forest from the study plot itself, the flooding brought an array of edge species (plant and animal) into the plot. (2) Construction of Rocky Gorge Reservoir upstream just before the beginning of the study altered the flooding regime of the tract; instead of being inundated periodically for short intervals several times each year, the water table is lower and the floods are fewer but more catastrophic. (3) Effluent from the Laurel sewage treatment plant now provides a substantial part of the total flow of the Patuxent River during the summer months. (4) In 1962, as part of a simulated pesticide study, 174 breeding birds including 169 individuals of neotropical species were netted and removed from the plot to study the rate of repopulation. The intent was to return the removed birds to the plot; however, the cooperating agency that was caring for the birds could not keep them alive and thus none of the warblers and flycatchers survived.

The density of neotropical migrants decreased during this study (table 1), but only one breeding species disappeared entirely: the Black-and-white Warbler.

The Pattern

The pattern is quite clear. It is essentially the same group of species that are declining in each study plot, and these birds are the long-distance migrants. The permanent resident species, on the other hand, tend to maintain their populations despite suburban sprawl and forest fragmentation; the short-distance migrants that have adapted to survival in edge habitats, such as jays, House Wrens, catbirds, robins, starlings, blackbirds, and towhees, also are maintaining their populations.

Summarizing table 1 (in which the data are presented in the original English measurements of the investigators): there was an overwhelming decrease in every long-distance (neotropical) migrant except the Veery; there was a decrease in density of breeding birds in every plot, even those with minimum disturbance; and the percentage decrease in long-distance migrants was consistently much greater than the decrease in the total population. If the densities of long-distance migrants are subtracted from the total densities, the sum of the densities of permanent residents and short-distance migrants in five plots (no densities are available from Laurel) dropped from 984.5 in the early studies to 968.2, a decrease of only 1.7%.

The only species that showed increases in any of the study plots in table 1 (out of 96 pairs of observations) were the following: Great Crested Flycatcher and Yellow-throated Vireo, both present in very small numbers, increased at Patuxent; the vireo was present every year, while the flycatcher nested erratically. There were very small increases in the Eastern Wood Pewee on the Seton Belt tract and the Red-eyed Vireo at Patuxent. The Wood Thrush increased substantially on the Seton Belt tract. The Veery, a recent invader from more northern breeding grounds, established itself or increased on three plots. The Louisiana Waterthrush increased by a fraction of a territory in Rock Creek Park.

A Sample Species, the Worm-eating Warbler

Let us consider briefly the breeding distribution in Maryland of one of the species that no longer nests in any of the study plots in figure 1, the Worm-eating Warbler. The map in Birds of Maryland and the District of Columbia (Stewart and Robbins 1958) showed this species as nesting throughout the Ridge and Valley, Piedmont, and Western Shore

Coastal Plain Sections except for the highly agricultural Hagerstown, Middletown, and Frederick valleys and the flat bayshore necks of Baltimore, Harford, and Cecil counties. It also nested in forested areas along the Pocomoke River and its main tributaries and at seven isolated spots elsewhere in the State. A portion of the present-day distribution, based on the Breeding Bird Atlas of the Piedmont counties of Montgomery and Howard (Klimkiewicz and Solem 1978), is shown in figure 3. This species is strictly limited to the few remaining areas of extensive woodland.

Supporting Evidence from Breeding Bird Survey

To further test the area sensitivity of forest species and to gather information on the minimum forest area required to maintain populations of various species, comparisons were made between bird counts and habitat factors at 500 Breeding Bird Survey (Robbins and Van Velzen 1969) stops scattered through central and eastern Maryland. Each 3-minute Breeding Bird Survey stop was visited annually in the early morning in June, and data for 1974-78 were used in the analysis. Thirty habitat characteristics were recorded at each stop. One of these was a measure of the acreage of contiguous forest in and adjacent to the quarter-mile radius counting circle. I should stress that the measurement of amount of woodland included not just the wooded area within the quarter-mile circle, but it also included all contiguous forest connected to woodland within the counting circle. For purposes of the analysis the forest was categorized into units expressed as powers of three. For example, forest plots of less than 3 acres (1.2 ha) were coded 0, those between 3^1 and 3^2 (3 to 9 acres, 1.2 to 3.6 ha) were coded 1, those between 3^2 and 3^3 (9 to 27 acres, 3.6 to 10.9 ha) were coded 2, etc. The highest category encountered was coded 8 (between 6,561 and 19,683 acres, 2,655 and 7,966 ha).

Correlation coefficients were computed for 72 bird species; the recorded abundance of each bird at each stop (5-year sum) was matched against each of the following habitat factors: percentage of coniferous, deciduous, and mixed woods within a circle of 400 m (one-quarter mile) radius, and height of the canopy; percentage of brush, plowed, cultivated, pasture, hay, lawn and fallow land, and of tidal estuaries, salt, brackish, and fresh marsh, and disturbed or industrial areas; number of houses and of visible snags; presence of hedges, electric wires, fences, streams and

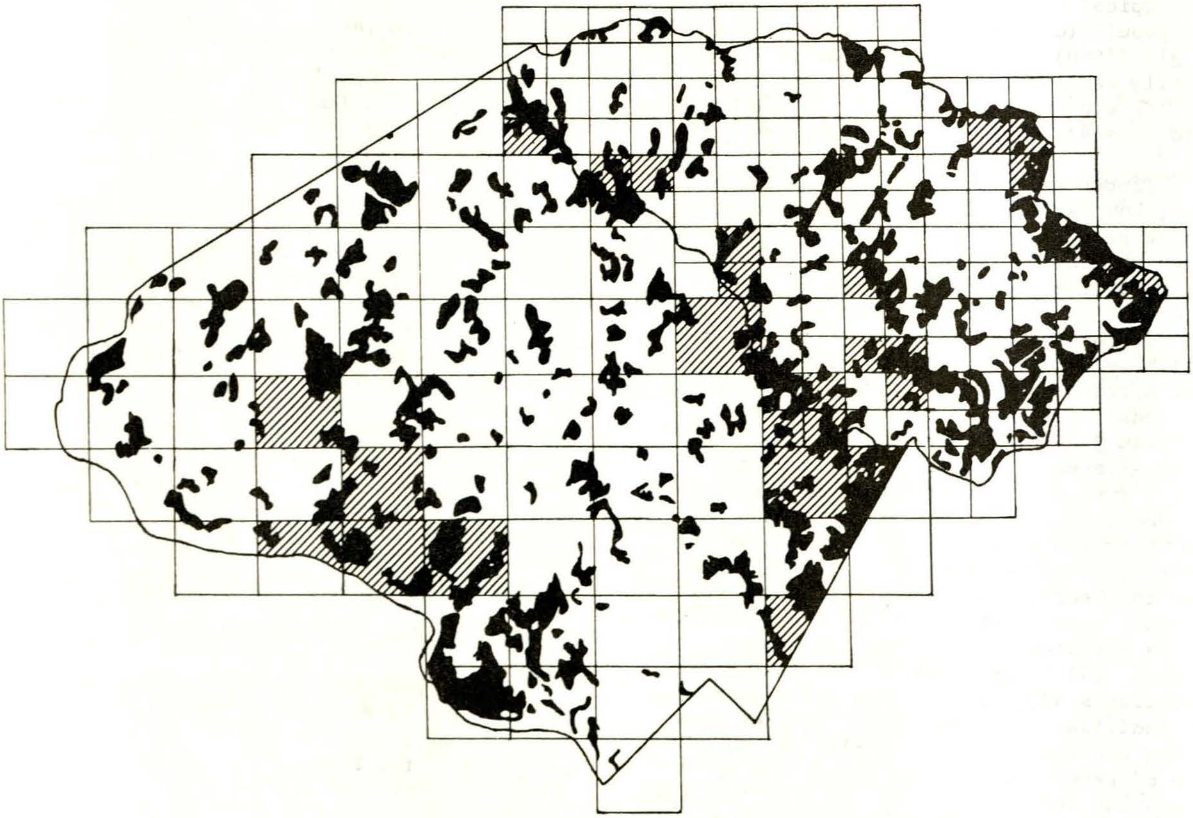

Figure 3.--Distribution of forest (solid black) and of breeding Worm-eating Warblers (shaded rectangles) in Montgomery and Howard Counties, Maryland. Data from Breeding Bird Atlas.

ponds; height of shrubs and width of roadside shoulder; also whether the road was paved, the time of morning when the bird counts were made, and the area of contiguous forest as described in the previous paragraph.

Considering only those correlations that were highly significant ($p < .01$) when each bird species was compared with each of 29 environmental factors, the only factor that was correlated with the abundance of more than half of the bird species was the area of contiguous forest (41 species). Other factors with a large number of highly significant correlations were: percentage of deciduous woods (36 species), percentage of coniferous woods, percentage of mixed woods and number of houses (24 species each), percentage of hayfield (23 species), and presence of fences (22 species).

Supporting Evidence from the Allegheny Mountains

In the Allegheny Mountains of Western Maryland and Western Pennsylvania, Deanna Dawson and colleagues from the Migratory Bird and Habitat Research Laboratory studied breeding bird populations with relation to numerical habitat descriptions in the summer of 1978. They included in their list of variables the same area measurement of contiguous forest that I had used in the above Breeding Bird Survey analyses. Their habitat variables were measurements of the tree size and density, shrub cover, canopy cover, ground cover, tree species, slope, and other criteria almost entirely different from those used in the Breeding Bird Survey analysis. It is important to note, however, that the one factor with the largest number of significant correlations with bird populations was the same one that was most significant in the Breeding Bird Survey analysis--the area of contiguous woodlands.

Determining Area Requirements for Sensitive Species

Problems in Making Estimates

Having established that a strong relationship exists between the extent of contiguous woodland and the populations of certain species of birds, the next question is one of defining the amount of contiguous forest needed for each of the area-sensitive species. Rough estimates can be obtained in several ways. One is to find the smallest forest fragment on which the species maintains at least one territory during the nesting season. The chief problem with this approach is that it does not take isolation into account. For example, MacClintock *et al.* (1977) found that a small fragment minimally isolated from a large continuous forest supported many of the neotropical migrant species characteristic of the larger woodland. Howe and Jones (1977) also pointed out that the least isolated of the small woodlots in southern Wisconsin supported the most species. Thus, any given small woodland is an integral part of a regional habitat mass that supports a regional population of the species in question. Subunits of this regional habitat mass are inadequate, by themselves, to support a population of sufficient size to retain genetic flexibility and to buffer against normal oscillations that characterize all populations. Also, it is difficult or impossible to know whether a given nesting attempt is successful, or even whether a singing male has a mate. Furthermore, it would be dangerous to draw conclusions from a single observation, which might be atypical. A pair of birds may succeed in rearing young in a year of super-abundant food. In years when food is in short supply, weather is abnormally wet, or predation is exceptionally high, nesting might be a complete failure. Thus, the critical area required for survival of an area-sensitive species is the area in which young can be produced in sufficient numbers to replace adult attrition under the poorest conditions of weather, food availability, competition from other wildlife, and other disturbances. All in all, the diversity of interacting factors presents a complex situation, and the investigator must exercize extreme caution in proposing "safe" definitions of forest area required.

Estimates from Breeding Bird Survey

To approach the problem in another way, I have computed for each area category the percentage of Breeding Bird Survey stops at which each area-sensitive species was recorded, using 5 years of data from 500 roadside stops in central and eastern Maryland. In this way I can determine not only the smallest forest fragment in which the species was recorded, but can determine at what point the frequency of occurrence begins to decrease as contiguous forest area decreases. Admittedly this method is biased to some degree by the proportion of the quarter-mile circle that is wooded, regardless of whether the woods are continuous or fragmented. In spite of this bias, there is for each of the area-sensitive species at least one point at which there is a noticeable decrease in frequency of occurrence. The percentage of stops at which Kentucky Warblers were found, for example, remained constant at about 13% at stops with 33 or more ha of contiguous forest, but dropped abruptly in smaller woodlots (fig. 4). The Ovenbird was found in the great majority of the very extensive forests, but was much less frequently recorded in the 885

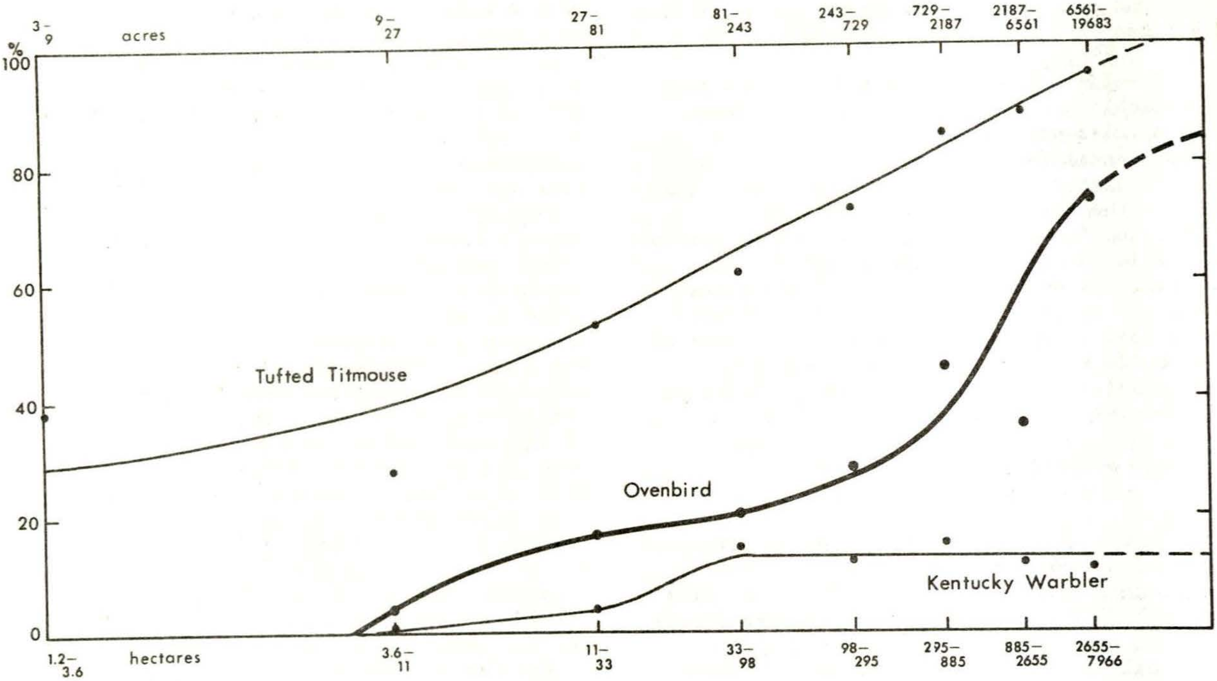

Figure 4.--Percentage of Breeding Bird Survey stops at which Tufted Titmouse, Ovenbird, and Kentucky Warbler were recorded. Stops are grouped according to the largest acreage of contiguous woodland present.

to 2,655 ha range; it was noted at nearly 20% of the stops with 11 to 98 ha of contiguous woodland, but at very few of the smaller woodlots (fig. 4). By comparison, the Tufted Titmouse, which is a permanent resident, did not show a sharp decline at any size class, and was present in woodlots of less than 3 ha. The size classes at which the frequency of occurrence of many of the area-sensitive species shows a sharp decline are presented in table 2, to give a preliminary estimate of the area sensitivity of each species.

From other breeding population data we know that figures in table 2 for the Worm-eating and Hooded Warblers are lower than the size these species require. This discrepancy results from an inadequate sample size for these species. Several of the other species registered an additional sharp decline at a lower size level: Ovenbird at 10 ha (fig. 4), and Wood Thrush and Red-eyed Vireo at 4 ha. The management concept shown by these studies is that large blocks of forest are necessary for the survival of entire nongame bird communities.

MANAGEMENT IMPLICATIONS

General Management Principles

From these early studies on forest fragmentation we can make some recommendations for management of forests to maintain or possibly increase the regional bird species pool. Some of these recommendations are counter to traditional game management approaches of opening up the forest to provide more shrub growth for deer or Ruffed Grouse. Openings do provide more food for certain species, most especially for support of seed-eating birds through the winter, but such openings as are desired for management of special interest species can be put in areas where they will not jeopardize a forest interior ecosystem.

First, a large undisturbed forest area needs to be maintained at all times. Where managed forests are contiguous with large natural areas (fig. 5a), such natural areas could serve as a nucleus for population maintenance. When the entire forest is subject to management, it is probably preferable to use a timber harvest rotation program under which a large contiguous tract remains undisturbed at any one time. Ideally,

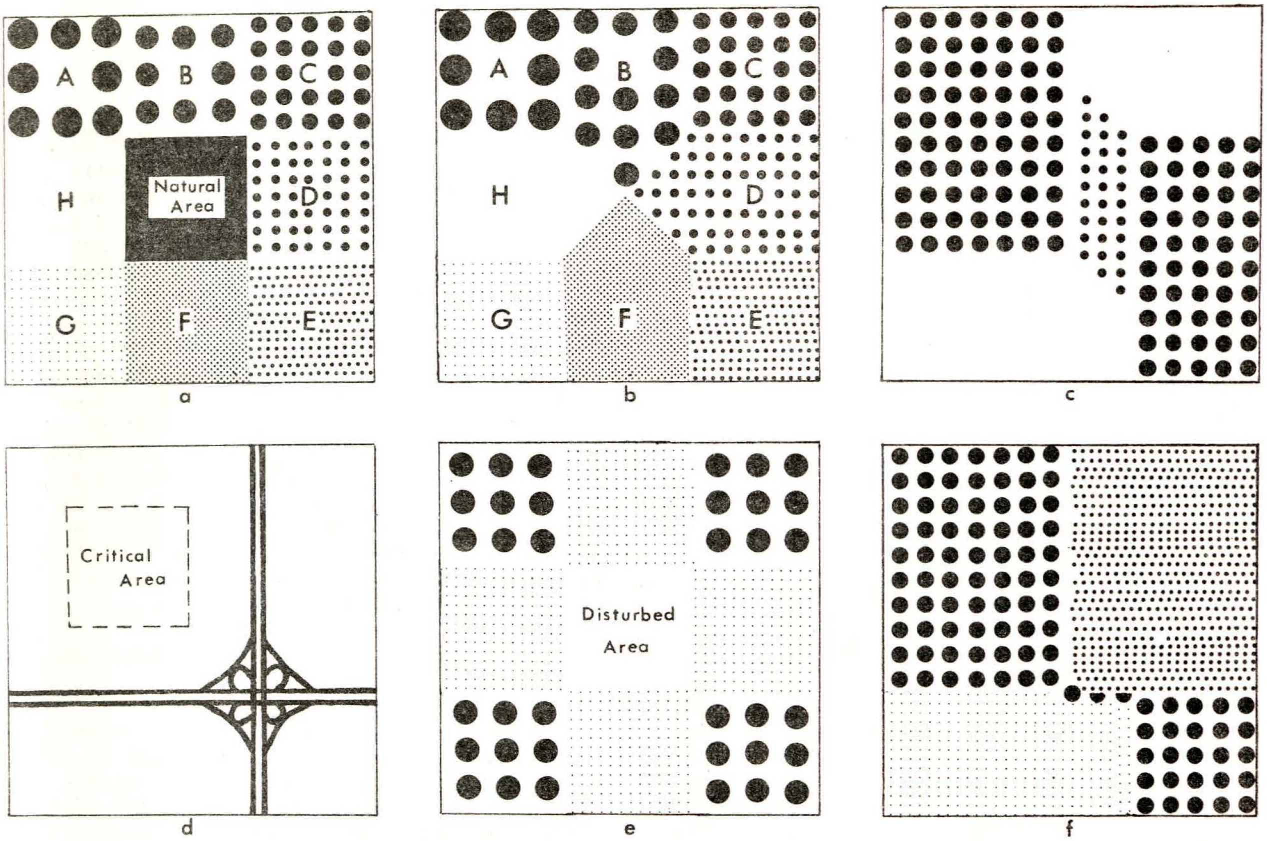

Figure 5.--Management implications for forests surrounded by other land use. Shading simulates age of forest.

a) Ideal management, with best opportunity to preserve all bird species present.
b) Good management, providing maximum adjacent habitat of each seral stage.
c) Avifauna can be preserved by planting to connect isolated woods with other forest.
d) Presence of highways or other disturbance requires change in management strategy.
e) Severe fragmentation leads to extinction of area-sensitive species.
f) Effects of fragmentation can be reduced by leaving connected wooded corridors.

harvest would occur in an orderly manner, such as a circular path (A, B, C, etc., in fig. 5b) with several hundred hectares cut in 1 or 2 years. The adjoining area would be cut several years later, and so on, in such a fashion that the bird population would move from one managed area to an adjacent one as the various seral stages moved across the landscape and as the area of mature forest gradually moved from one spot to another.

Robert Whitcomb (pers. comm.) has pointed out that when running Breeding Bird Survey routes in the West Virginia mountains he has been impressed with the great variety and abundance of warblers in areas heavily lumbered and disturbed by strip mining. Although most of the woods are in early and middle stages of growth, management has been in large units and the avian species pool has been preserved. Another advantage of managing forests in units of several hundred hectares is that disturbance in any given season is restricted to a small part of the entire management area. Conversely, if timber is harvested in many small isolated plots in the same season, the operations will impact not only the birds in the several plots, but also those along many access trails in other portions of the management area. Aesthetically, management of much smaller units might be more pleasing; but if we wish to maintain the integrity of the entire ecosystem, fragmentation into small blocks (fig. 5e) should be avoided where possible.

In states where forests are already greatly fragmented, one should view a forest management plan in the context of the adjoining forest areas and strive to coordinate management practices with nearby land owners to prevent inadvertent loss of area-sensitive species through simultaneous destruction of sources of avian repopulation.

These recommendations are derived from research on bird populations; however, they might apply to other forms of life as well. Special management techniques should be considered for locally sensitive species.

Table 2. Preliminary estimates of minimum forest areas required to sustain viable breeding populations of area-sensitive forest birds, based on 500 Breeding Bird Survey stops in central and eastern Maryland.

Species	Frequency[1]	Critical size[2] Acres	Critical size[2] Hectares
Red-shouldered Hawk	14	250	100
Red-bellied Woodpecker	225	10	4
Hairy Woodpecker	22	10	4
Great Crested Flycatcher	146	25	10
Acadian Flycatcher	53	80	30
Eastern Wood Pewee	127	10	4
Blue Jay	262	10	4
Tufted Titmouse	294	10	4
Carolina Wren	300	25	10
Wood Thrush[3]	304	250	100
Yellow-throated Vireo	27	250	100
Red-eyed Vireo[3]	276	250	100
Black-and-white Warbler	24	750	300
Prothonotary Warbler	9	250	100
Worm-eating Warbler[3]	9	750	300
Northern Parula Warbler	19	250	100
Pine Warbler	71	80	30
Ovenbird[3]	84	6550	2650
Louisiana Waterthrush	6	250	100
Kentucky Warbler[3]	32	80	30
Hooded Warbler[3]	17	80	30
Scarlet Tanager	133	250	100
Summer Tanager	45	250	100

[1] Number of stops at which the species was found.
[2] Area at which the sharpest decrease occurred.
[3] See text for comment.

Snags

During the past 6 years several investigators have emphasized the value of snags to wildlife (e.g., see Conner 1978). There is no question that presence of snags will increase populations of hole-nesting species, especially in the early successional habitats containing few natural cavities. Snags also are used as perches for many species other than cavity nesters. Although snags increase the populations of some species, they may cause a decrease in others by introducing edge conditions into a forest interior. I doubt that anyone will challenge the benefits of leaving snags at or near the edge of a managed forest, but one must consider the consequences of permitting snags to be retained intentionally in forest interior situations. The principal problem is that snags are used by cowbirds for watching the activities of other species in whose nests they will lay their own eggs. Brown-headed Cowbirds have been increasing steadily since at least the mid-1960's (Bystrak and Robbins 1977), and are having a greater impact on nesting success of small insectivorous birds. Mayfield (1977) found the Brown-headed Cowbird to be one of the most serious threats to survival of the endangered Kirtland's Warbler. The introduction of cowbirds into forest interior situations where they do not normally occur (Lowther and Johnston 1977) will have a detrimental effect on many of the neotropical insect-eating migrants that are restricted to the forest interior. The forest interior specialists are not adapted to cope with nest parasitism from the cowbird. Nearly all build open nests that are easily found by the cowbird, and most also raise only a single brood per year; thus, cowbird parasitism may destroy their entire annual production.

I am not saying that snags are bad in all interior situations, but I stress that if use of snags is promoted in the forest interior such snags should be clustered in a few areas rather than permitted to exist throughout a managed forest. Furthermore, when feasible, I recommend that tall snags that break the canopy be removed and shorter snags within the canopy be retained because cowbirds tend to select exposed perches.

Bear in mind that snags at or near a forest edge will frequently attract nesting Starlings, and the Starlings in turn compete with native hole-nesting species, especially flickers, Red-headed Woodpeckers, and bluebirds.

Reservoirs

One of the greatest disasters that can befall a forest bird community is the creation of a reservoir. In large sections of north central and northeastern United States the most extensive wooded areas are those in stream valleys. When such valleys are impounded for water supply, flood control, or recreation purposes, the more moist and generally most productive forest areas are destroyed, and many of the adjacent upland forest areas are fragmented to the point that they can no longer support the area-sensitive species of migratory birds. As an example, I would like to refer again to Rocky Gorge Reservoir near my home (fig. 6). Within the flooded basin of the reservoir, all of the lowland forest was destroyed. In addition, the remaining upland has been fragmented so

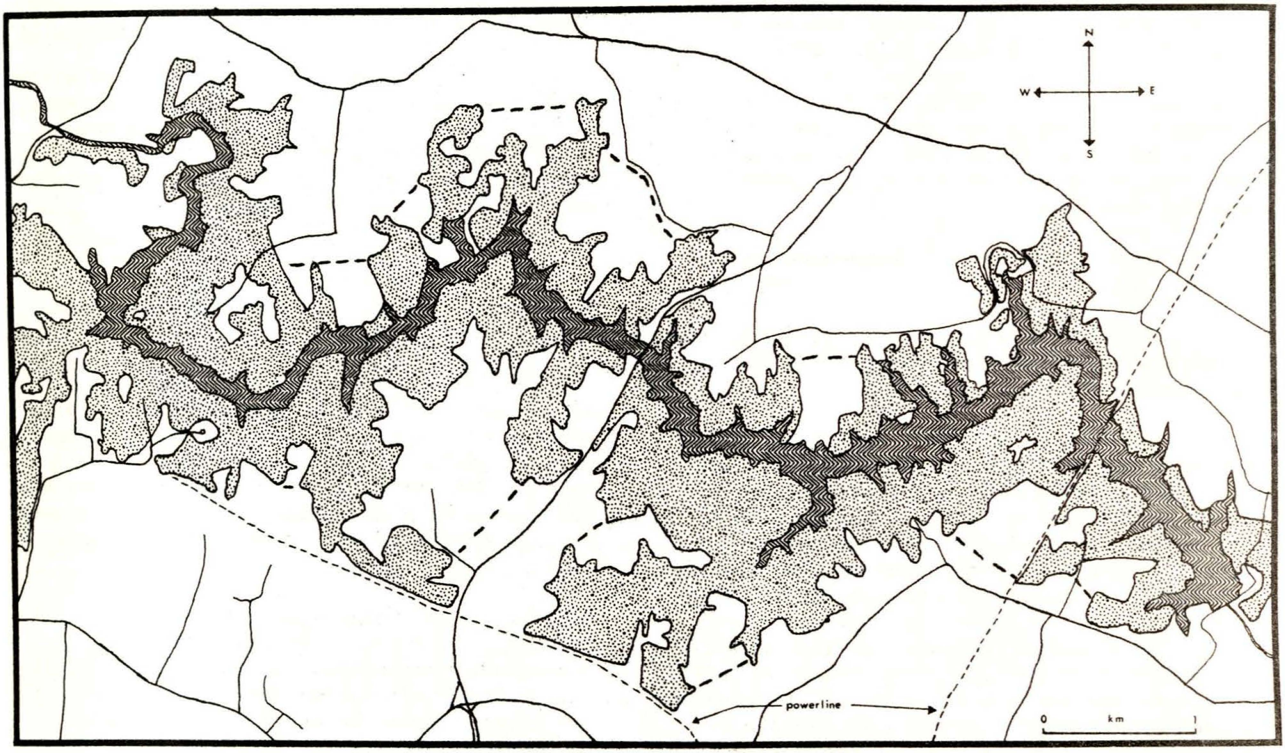

Figure 6.--Excessive fragmentation by Rocky Gorge Reservoir could have been prevented by planting forest within the dashed lines prior to destroying the original forest.

that now there is not a single point in the forest that is more than 300 meters from the forest edge. Although small numbers of many of the area-sensitive species still persist on these fragments, it is almost certain that these populations are doomed. The proximity of edge conditions throughout the area must inevitably lower reproductive rates of the present population, and there is no longer an adjacent mesic forest of higher productivity that can serve to offset losses in the peripheral population.

My reason for citing this example is that by means of proper long-range planning it would have been possible to protect or plant forest in strategically located areas adjacent to the impoundment before construction of the reservoir. If some of the areas marked with heavy dashed lines in figure 6 had been planted to forest before the area along the river was cut, several large areas of contiguous forest could have been retained, giving additional protection to the watershed and also providing refuge areas that could have served to perpetuate most of the avifauna typical of the original forest.

Corridors

One way to reduce the loss of area-sensitive species from forest fragments is by leaving (or planting) corridors that connect the fragment with a larger forested area (fig. 4f; see also MacClintock et al. 1977). The corridor concept has also been used successfully to bring woodland birds closer to residential areas during the non-breeding periods. Very few studies have documented effects of corridor width on bird populations, so no specific recommendations can be made now regarding the preferred width of such corridors or the extent that they are beneficial to certain species. Right now, I can only recommend retention of even a narrow corridor to prevent complete isolation of forest fragments. The corridor concept could also be carried too far. If a large number of small fragments were connected by corridors from the same source of repopulation, birds from a main forest might be enticed into fragmented woodlots where increased predation, competition from edge species, and other factors would prevent successful rearing of young (Whitcomb et al. 1979).

MANAGEMENT RECOMMENDATIONS

The following 16 recommendations stress steps that can be taken to retain the obligate forest-interior species in the breeding population. Nearly all of the edge species and those of the various seral stages will find suitable habitat regardless of the management techniques employed; these species are not so dependent upon large contiguous areas of similar habitat. Thus, most edge species of birds are not in danger of being eliminated from the species pool.

1. Avoid unnecessary fragmentation of forests (fig. 5e).

2. Manage in large blocks, or in such a way that small blocks are adjacent to more extensive forest.

3. In long-range plans designate tracts that will be mature or nearly mature at each stage in the management plan, and design normal management operations in such a way that repopulation of disturbed areas can proceed via wooded connections or over the smallest possible gaps in forest cover.

4. When possible, use a fairly uniform plan of rotation cutting (fig. 5a,b) so that the oldest sections at any time are adjacent to each other and the younger stages are adjacent to themselves, making the maximum usable area available to each bird species, no matter what its requirements.

5. Plan cooperatively with adjacent landowners so that maximum repopulation potential of those species that require extensive mature or near mature forest can be achieved.

6. In areas where mature forest is limited, consider preserving one or more strategically located mature tracts to serve as sources of avian repopulation.

7. In any management plan designate areas that are especially sensitive during any particular period of the year; and by posting or other means keep disturbance such as camping, hiking, picnicking, fishing, surveying, marking, or cutting to a minimum during the nesting season (May through early August).

8. When public use is part of a forest management plan, restrict activities to the edge of a sensitive area rather than permitting them to extend into its center.

9. Retain vegetational diversity to the extent feasible, because many studies have demonstrated a direct relation between vegetational diversity and avian diversity. It is not necessary to maintain high diversity in each separate management unit as long as there is diversity among different units. Grazing reduces diversity by removing or greatly reducing one or more of the important components of the forest vegetation.

10. Pending conclusion of more definitive studies on minimum habitat area requirements of various avian species, think in terms of 1,000 contiguous hectares (2,500 acres) of forest canopy as a desirable goal to preserve most or all of the avian species pool.

11. In smaller tracts (even down to 2 ha or less) it is beneficial to maintain the maximum contiguous woodland with the least amount of edge.

12. Management units that approach a square are much more effective in preserving forest-interior birds than are long, narrow ones--especially when managed tracts are small. The portions of a forest that are most beneficial to neotropical migrants are several hundred meters or more away from the forest edge.

13. Leave snags along forest edge or in patches in the forest interior, but not throughout the forest. In the forest interior select for preservation those snags that will not extend above the canopy of the nearly mature forest.

14. In any management plan consider the disruptive effects of other projects such as existing or proposed super highways, impoundments, transmission line corridors, or sewer lines (fig. 5d). Check with appropriate agencies on the timing of new construction, to avoid inadvertent loss of a critical area at the wrong time.

15. With reference to recommendation 14, provide mitigation planting as far in advance of the impending disturbance as possible (fig. 6).

16. If wooded fragments must be isolated from the forest proper, retain a connecting corridor, such as along a stream; or if a forest tract has already been separated, consider planting a corridor to reconnect it (fig. 5c,f).

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APPENDIX

Scientific Names of Birds

Area-sensitive Species

Nonpasserines

Red-shouldered Hawk	Buteo lineatus
Broad-winged Hawk	Buteo platypterus
Yellow-billed Cuckoo	Coccyzus americanus
Whip-poor-will	Caprimulgus vociferus
Ruby-throated Hummingbird	Archilochus colubris
Pileated Woodpecker	Dryocopus pileatus

Flycatchers

Great Crested Flycatcher	Myiarchus crinitus
Acadian Flycatcher	Empidonax virescens
Eastern Wood Pewee	Contopus virens

Thrushes

Wood Thrush	Hylocichla mustelina
Veery	Catharus fuscescens

Vireos

Yellow-throated Vireo	Vireo flavifrons
Red-eyed Vireo	Vireo olivaceus

Wood Warblers

Black-and-white Warbler	Mniotilta varia
Prothonotary Warbler	Protonotaria citrea
Worm-eating Warbler	Helmitheros vermivorus
Northern Parula Warbler	Parula americana
Pine Warbler	Dendroica pinus
Ovenbird	Seiurus aurocapillus
Louisiana Waterthrush	Seiurus motacilla
Kentucky Warbler	Oporornis formosus
Hooded Warbler	Wilsonia citrina
American Redstart	Setophaga ruticilla

Tanagers

Scarlet Tanager	Piranga olivacea
Summer Tanager	Piranga rubra

Other Species Mentioned

Ruffed Grouse	Bonasa umbellus
Red-bellied Woodpecker	Melanerpes carolinus
Red-headed Woodpecker	Melanerpes erythrocephalus
Hairy Woodpecker	Picoides villosus
Blue Jay	Cyanocitta cristata
Tufted Titmouse	Parus bicolor
White-breasted Nuthatch	Sitta carolinensis
House Wren	Troglodytes aedon
Carolina Wren	Thryothorus ludovicianus
Starling	Sturnus vulgaris
Kirtland's Warbler	Dendroica kirtlandii
Prairie Warbler	Dendroica discolor
Brown-headed Cowbird	Molothrus ater
Orchard Oriole	Icterus spurius
Blue Grosbeak	Guiraca caerulea

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Thursday, January 25

SPECIALIZED HABITAT CONSIDERATIONS FOR NONGAME BIRDS

Moderator: Charles J. Griffith
National Wildlife Federation

SNAG MANAGEMENT

Keith E. Evans and Richard N. Conner[1]

Abstract.--Thirty-six of the 85 North American cavity nesting bird species occur in the north-central and northeastern forests. Species richness and density are influenced by the quality and quantity of available snags. Snag abundance is influenced by many land use options including timber operations. We have calculated the snag needs for 9 primary excavators and have related these needs to management options.

Only recently have wildlifers expressed great concern for animals that depend on the dead and dying tree (snag) component of the forest--especially for avifauna classified as cavity nesters. These birds evolved in unmanaged forest stands where snags occur naturally and are dependent on snags for at least a portion of their life requirements. Since 90 percent of the trees present in an upland hardwoods stand at age 20 will die during the next 60 years (Gingrich 1971), there are many standing dead and dying trees found in naturally developing forests.

Each resource discipline views the snag component of forests differently. Foresters know that growth can be increased and mortality decreased by periodically thinning forest stands. Thinning a forest selects against subdominant, low-vigor, silviculturally defective and low-quality trees--trees that have the highest potential to become suitable snags. Snags and potential snags are often referred to as "ugly" by the landscape architects, and "hazards" by the forest protection and safety divisions. Although these concerns are occasionally valid, across the board condemnation is unwarranted.

The objectives of this paper are to (1) identify bird species that depend on snags, (2) discuss the specialized requirements of these bird species, (3) relate snag attributes to management options for bird species, (4) calculate the number of snags required, and (5) make management recommendations.

EXPLANATION OF TERMS

Snag

A snag is a standing dead or partially dead tree. Snag attributes and the requirements of birds depending on these attributes vary greatly. Generally, the value of a snag increases as its size increases. Snags less than 10 cm d.b.h. and/or less than 2 m tall have little value for feeding and nesting birds. The snag characteristics of primary interest are natural cavities and a condition that makes a snag suitable for cavity excavation (fig. 1).

Hard and Soft Snags

The classification of a snag as "hard" or "soft" is somewhat subjective. Generally, hard snags are dead or partially dead trees with at least some limbs remaining and with fairly sound wood. Soft snags are in advance stages of decomposition and rarely have limbs.

Natural Cavity

A space hollowed out of a tree by a force other than a bird. These holes are commonly created by fungal rot, insects, fire, or the breakage of the wood fiber.

Primary Excavator

A bird species that excavates or hollows out a space within a snag for nesting or roosting. The woodpeckers are the major group of primary excavators. Their habit of excavating partial or complete cavities in excess of their needs provides the major supply of cavities for secondary users.

Secondary Users

A bird species that nests or roosts in a natural cavity or a cavity excavated by a primary excavator. Certain species, such as the black-capped chickadee, can be both a primary excavator and secondary user.

Bark Cavity

A space created by loose bark. These spaces are used by insects, reptiles, amphibians, mammals, and birds, e.g., brown creepers.

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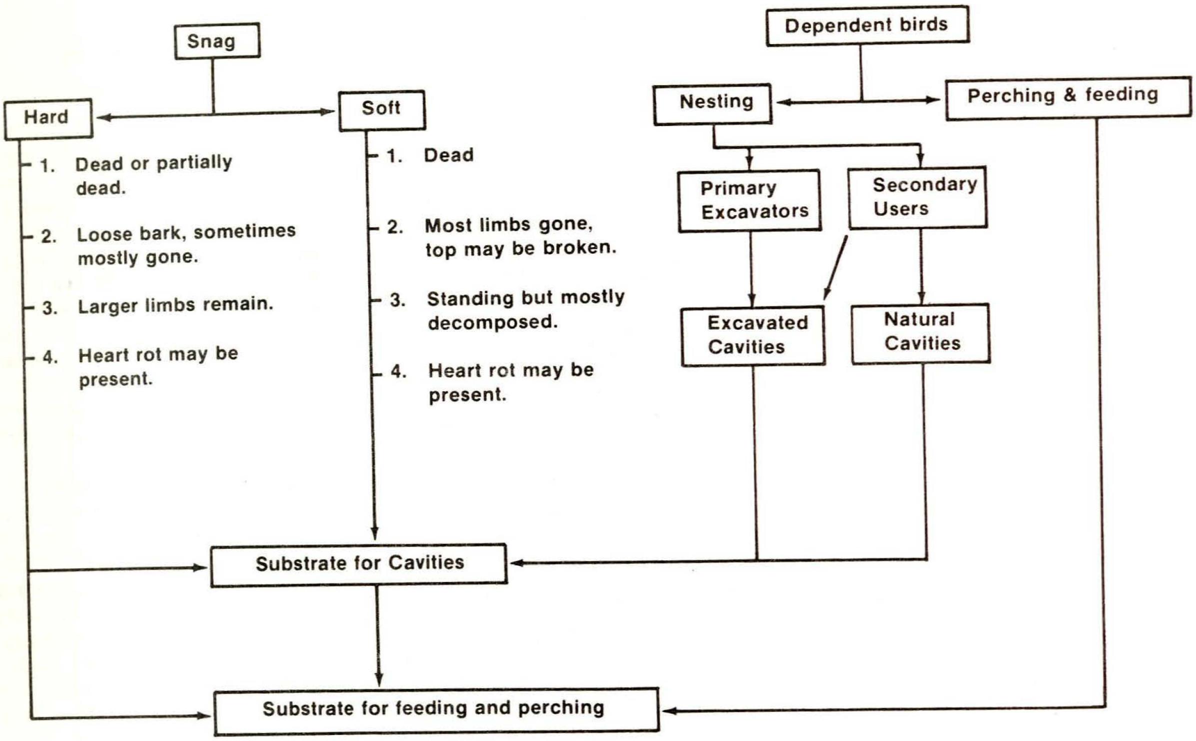
Snag
Hard
Soft
1. Dead or partially dead.
2. Loose bark, sometimes mostly gone.
3. Larger limbs remain.
4. Heart rot may be present.
1. Dead
2. Most limbs gone, top may be broken.
3. Standing but mostly decomposed.
4. Heart rot may be present.
Dependent birds
Nesting
Perching & feeding
Primary Excavators
Secondary Users
Excavated Cavities
Natural Cavities
Substrate for Cavities
Substrate for feeding and perching

Figure 1.--*Diagram of snag types and generalized use patterns.*

Usually formed after a tree or tree limb has died.

Woodpecker Territories

Disagreement exists in the literature as to what type of territories different species of woodpeckers defend. Lawrence (1966) reported that several species in Ontario defended nesting and mating territories (type B) (Nice 1941). Brenowitz (1978) and others have noted that sizes of defended areas for many species varied within species depending on the species intruding; thus, a pair may defend nesting, mating, and foraging territory (type A) when interacting with one species, and Type B territory when interacting with another.

The values used for sizes of woodpecker territories in this paper include the area used by pairs for nesting, mating, and foraging--a type A territory using the code developed by Nice (1941). Also, for some of the woodpecker species examined in this paper, the word "range" may be more scientifically correct than the word "territory".

DEPENDENT BIRD SPECIES

Some 85 species of North American birds nest and/or roost in dead or deteriorating trees (Scott *et al.* 1977). These species either excavate cavities, use cavities created by decay or breakage, or use cavities constructed by other species. The snag-dependent species--hole nesters--make up 20 percent of the bird species encountered on the breeding bird survey routes in Missouri (Evans and Dawson 1976). Most of these species are insectivorous, and may help control insect populations that damage timber. The winter bird populations in the northeast consist of an even higher percentage of cavity-dependent birds. Bock and Lepthien (1974) found that the average Christmas bird count for the northeast contained 40 species of birds. The list of birds we are considering in this paper (table 1) contains 26 species that winter in the area.

Although the hole nesters have some common characteristics and requirements, they are a diverse group. They range in size from 11-1500 grams and utilize territories from less than 1 ha to over 140 ha (table 1). Management options must be equally diverse. We have simplified the management proposals by (1) concentrating our comments on the primary excavators, and (2) considering only the snag component of their life requirements. If suitable numbers and sizes of snags are provided for primary excavators, the snag requirements of secondary users hopefully will be attained.

SUITABILITY OF HARDWOOD AND PINE SNAGS AS CAVITY SITES

Recently, the importance of snags in forests and lumbered areas has become widely recognized

Table 1.--*Characteristics of cavity-nesting birds of the northeastern United States*

Species[1]	Snag use				Hard snags	Soft snags	Secondary	Optimum d.b.h. (cm)				N. hardwood	Lowland hardwood	Aspen-birch	Oak	Pine	Upland conifer	Lowland conifer	Hole size	Box size			Territory size	Body weight
	Feed	Perch	Nest	Roost				10	20	30	50+									Length	Width	Height		
																			- - - *cm* - - -				*ha*	*g*
Wood duck			X				X				X		X						10	25	25	60		
Common goldeneye			X				X				X							X	10	30	30	60		
Hooded merganser			X				X				X		X					X	10	25	25	60		
Common merganser			X				X				X							X	12	25	25	90		
Turkey vulture		X	X				X				X	X	X	X	X	X								1500
Peregrine falcon		X	X				X				X	X		X			X							
Merlin		X	X				X				X			X	X		X							
American kestrel		X	X				X			X		X	X	X	X	X	X	X	8	25	25	40	142	115
Barn owl		X	X	X			X				X	X	X		X	X			13	33	38	40		500
Screech owl		X	X	X			X			X		X	X	X	X	X	X	X	8	20	20	30		178
Barred owl		X	X	X			X				X	X	X		X				20	33	38	40		800
Boreal owl		X	X	X			X			X							X	X	7					
Saw-whet owl		X	X	X			X			X				X	X	X	X		6	15	15	30	40	90
Chimney swift			X	X			X				X	X	X	X	X	X	X	X		Chimneys				
Common flicker	X	X	X	X	X	X	X			X		X	X	X	X				7	18	18	40	16	134
Pileated woodpecker	X	X	X	X	X	X					X	X	X		X	X			10				70	230
Red-bellied woodpecker	X	X	X	X	X	X				X		X	X		X	X							6	62
Red-headed woodpecker	X	X	X	X	X	X					X	X		X	X				5				4	66
Yellow-bellied sapsucker	X	X	X	X	X	X				X			X	X	X	X	X						4	47
Hairy woodpecker	X	X	X	X	X	X				X		X	X	X	X	X	X		4	15	15	35	8	44
Downy woodpecker	X	X	X	X		X			X			X	X	X	X	X	X	X	3	10	10	25	4	27
Black-backed three-toed woodpecker	X	X	X	X	X	X				X							X	X.					30	
Northern three-toed woodpecker	X	X	X	X	X	X				X							X	X					30	
Great crested flycatcher		X	X				X			X		X	X	X	X				5	15	15	25		34
Tree swallow			X				X			X			X		X			X	4	12	12	15		20
Purple martin			X	X			X			X		X		X	X	X			6	15	15	15	3	43
Black-capped chickadee			X			X		X				X		X	X	X	X		3	10	10	25	1.5	11
Boreal chickadee			X			X		X						X			X	X	3	10	10	25		
Tufted titmouse			X	X			X			X			X		X				3	10	10	25		23
White-breasted nuthatch	X		X	X			X			X		X	X	X	X	X	X	X	3	10	10	25	0.8	20
Red-breasted nuthatch	X		X	X		X	X			X							X	X	3	10	10	25		
Brown creeper	X		X	X			X			X		X				X	X	X				25		9
House wren			X	X			X			X			X	X	X	X	X	X	3	10	10	20	0.5	11
Winter wren			X				X		X							X	X		3					9
Eastern bluebird		X	X	X			X		X			X		X	X				4	12	12	20	1.0	30
Prothonotary warbler			X				X		X				X										1.5	16

[1] Scientific names in Appendix A.

(McClelland and Frissell 1975, DeGraaf 1978, Scott 1978). Techniques to calculate the number of snags required by individual species appeared in Balda (1975), Bull and Meslow (1977), and Thomas *et al.* (1976). The snags provided should be suitable for nest cavity excavation. To be suitable for cavity sites, snags should be large enough in diameter and have decayed heartwood at a height appropriate for a bird species to excavate a nest cavity (table 2). Primary excavators prefer trees with heart rots because the soft, rotted wood facilitates cavity excavation (Conner *et al.* 1976).

Several states of decay are suitable for cavity excavation, but some are better "quality" for nest sites than others. The best quality nest site is a live tree with a "top rot", decayed heartwood in the upper trunk or main limbs of the tree. Such trees have a firm sapwood which is highly effective as a defense against predators (Kilham 1971, Conner 1977b). Top-rotted trees are often used by woodpeckers when nesting in hardwoods (Conner *et al.* 1975).

A less defensible nest tree is one having both heart and sap rotting fungi present at the site of the nest cavity. Sap rots infect the sapwood of trees, softening it and killing the affected tree or limb. If the sapwood is soft, predators can easily enlarge the cavity entrance tube and prey on young or adults. However, certain species that are not strong excavators (e.g., downy woodpeckers[2/]) may be partially dependent on snags with both heart and sap rots when they nest in trees with "hard" wood, e.g., oaks, hickories, etc. (Conner 1978).

Beetle-killed pines are an additional type of snag available for cavity nesters. These snags are often quite soft because invading beetles and broken branches have exposed most of the wood to fungal attack. Due to extensive decay in both sapwood and heartwood these snags often do not stand for long periods of time.

The least desirable nest tree condition occurs when only the sapwood of a snag is rotted. When a nest cavity is excavated into just the sapwood, the cavity is quite vulnerable to predation, and possibly temperature extremes. The thickness of wood between the cavity and the outside of the tree is typically minimal in such cavities. Thus, the insulation value of the cavity (Kendeigh 1961) may be greatly reduced.

Possible Indicators of Suitable Snags

Snags with potential nest sites have many indicators (Conner 1978). Fungal conks, rotting dead branch stubs, old wounds or scars, existing woodpecker cavities, and dead portions on trees are some obvious characteristics indicating the possible presence of a suitable substrate. Coring snags with an increment borer and/or culturing fungi from these cores are more difficult methods to determine suitability of snags (Conner *et al.* 1976).

SNAGS AS FORAGING SUBSTRATES

In addition to their importance as nest sites, snags are used extensively by many birds as foraging sites. The surface of a live tree is a complex habitat. Crevices formed by the bark provide sites for spiders, ants, moths, and other invertebrates to hide. These invertebrates are the mainstay diet of the bark gleaning birds.

As a tree dies, it is invaded by many additional insects. Noteworthy of these are the numerous species of bark beetles that feed in the cambium of the tree. Larvae, pupae, and adults are a major food item of many woodpeckers (Otvos 1965). Woodpeckers extract the larvae of these insects after pecking small holes through the bark. Later in the beetles' life cycle woodpeckers need to make excavations to gain access to larvae that have gnawed a tunnel into the sapwood to pupate.

Additional prey are found in the heartwood of the snags. Carpenter ant (*Camponotus* spp.) and termite (Isoptera) colonies are rich food supplies for woodpeckers strong enough to penetrate the tree shell protecting the caverns (Conner 1977a).

CALCULATION, SIZES, AND DISTRIBUTION OF SNAGS REQUIRED

In this paper we have used the formula developed by the U.S. Forest Service (Bull and Meslow 1977) to calculate the number of snags required by species:

$$Y = A \times B \times C$$

Where: Y = number of suitable-sized snags required standing at any given time per 40 ha (100 acres).
A = maximum bird species density per 40 ha (100 acres).
B = number of snags used annually (or for a specific season).
C = snag reserve, some snags will fall and need replacement, some available snags will be unsuitable for cavity excavation, and some snags will be used as feeding but not nesting sites.

[2/] Scientific names in Appendix.

Table 2.--*References and characteristics of territories and nest trees needed to calculate snag densities for 9 species of woodpeckers common to the northeastern United States*

Species	When using territory	Territory size		Minimum no. of snags used	Average d.b.h. of nest trees		Average height of nest trees		Maximum pairs per:		Literature
		ha	*(ac)*		*cm*	*(in)*	*m*	*(ft)*	100 ha	(100 ac)	
Downy woodpecker	All year	4	(10)	4	20	(8)	6	(20)	25	(10)	Allen (1928), Kilham (1962), Lawrence (1966), Conner *et al.* (1975, & unpublished data), Bull (1978)
Hairy woodpecker	All year	8	(20)	4	30	(12)	9	(30)	12.5	(5)	Kingsbury (1932), Kilham (1960, 1966, 1968), Lawrence (1966), Conner *et al.* (1975)
Pileated woodpecker	All year	70	(175)	4	55	(22)	18	(60)	1.4	.6	Becker (1942), Tanner (1942), Hoyt (1957), Kilham (1959, 1976), Conner *et al.* (1975), Bull (1978)
Common flicker	Breeding	16	(40)	2	37	(15)	9	(30)	6.3	(2.5)	Lawrence (1966), Conner *et al.* (1975), Bull (1978)
Red-bellied woodpecker	All year	6	(15)	4	45	(18)	12	(40)	16.7	(6.7)	Tanner (1942), Kilham (1958a), Boone (1963), Stickel (1964), Reller (1972), Conner (1973), Jackson (1976)
Red-headed woodpecker	Breeding	4	(10)	2	50	(20)	12	(40)	25	(10)	Kilham (1958b), Reller (1972), Conner (1976, & unpublished data), Jackson (1976)
	Winter	.1	(.3)	1	50	(20)	12	(40)	1000	(333)	
Black-backed three-toed woodpecker	All year	30	(75)	4	38	(15)	9	(30)	3.3	(1.3)	Bent (1939), Short (1974), Bull (1978), (Territory size assumed to be same as northern three-toed woodpecker)
Northern three-toed woodpecker	All year	30	(75)	4	35	(14)	9	(30)	3.3	(1.3)	Laing and Taverner (1929), Bent (1939), Gibbon (1966), Bull (1978), Thomas *et al.* (Unpublished manuscript)
Yellow-bellied sapsucker	Breeding	4	(10)	1	30	(12)	9	(30)	2.5	(10)	Howell (1952), Lawrence (1966), Kilham (1971, Personal communication), Bull (1978), Thomas *et al.* (Unpublished manuscript)

Maximum Density

A maximum population density must be used in order to determine what number of snags are needed to support this density. Territory sizes and densities of pairs listed in table 2 are based on values found in the literature. In a few cases assumptions and adjustments were needed. Due to a lack of information, the territory size of black-backed three-toed woodpeckers was assumed to be similar to northern three-toed woodpeckers. Since the black-backed three-toed woodpecker is larger than the northern three-toed, it probably required a larger territory; thus our assumption may provide slightly more snags than the bird actually requires as a maximum.

Many population densities have been reported for pileated woodpeckers; the highest being one pair per 106 acres (Tanner 1942). However, this value was measured in southern United States where food may be more abundant for a longer portion of the year than in northeastern United States. Thus, we adjusted territory size to one pair per 175 acres to obtain what is probably a more realistic maximum for the Northeast. This value, 175 acres or 70 ha, is also the range size reported for pileateds by Kilham (1976).

Number of Snags Used Annually

Woodpeckers use cavities in trees for nesting and roosting. If all conditions are favorable, a pair of woodpeckers uses only one nest cavity annually. However, often predators and competitors cause a cavity to be unsuitable (Allen 1928, Balda 1975).

Ideally, only two roost cavities are needed annually. Field observations, however, indicate that several roost cavities per individual bird may be needed as both sexes frequently move to different roost cavities (Allen 1928, Hoyt 1957, Stickel 1964). Natural selection may have favored this behavior to reduce losses of roosting woodpeckers to nocturnal predators.

After fledging, young woodpeckers of most species require roost cavities, which adds at least one more cavity to the annual requirement. Thus, for most woodpeckers, pairs require a minimum of 4 suitable cavity trees (or snags) each year (table 2). Annual cavity requirements are different for the migratory woodpeckers, common flickers, yellow-bellied sapsuckers, and red-headed woodpeckers, as they need winter roosting sites in a different area than nesting sites.

Reserve of Snags

It is difficult, if not impossible to determine the percentage of snags in a forest that are suitable for cavity excavation. Thomas *et al.* (1976) reported that only one snag out of 17 in Oregon contained a nest cavity. This however, does not preclude the possibility that some of the 16 unused snags were suitable for cavity excavation. Availability of food, as suggested by McClelland (1979), may be a limiting factor that reduces woodpecker densities in the Pacific Northwest. Low population densities of cavity excavators and/or spacing of snags may cause some suitable snags to be unused. Variations in the percentage of snags that are suitable for cavity excavation will be influenced by site characteristics, geographical location, and the species of the tree involved. In addition, a reserve of snags is needed to replace cavity trees lost each year.

We have used the value 10 as an estimate of the number of snags needed to provide cavity substrate for each cavity required by a pair of woodpeckers. This value includes a margin for unusable snags, a reserve of snags for replacements, feeding habitat, and a supply for secondary users.

Snags Required to Support Percentages of Population Maximums

Once the number of snags required to support maximum densities of woodpecker species is determined (Y in the formula), various percentages of these values can be used to estimate the number of snags required to support percentages of population maximums (table 3). These values are estimates based on the best information currently available. If future research provides more accurate base data, the estimates of snags required should be recalculated and the new values used for habitat management projects in the field.

Snag Height and DBH

Thomas *et al.* (1976) and Bull (1978) mentioned the use of minimum heights and DBH's of snags when providing snags for cavity nesters. We discourage the use of minimum values.

The DBHs and heights of species' nest trees tend to be normally distributed, most observation falling near the mean and few at the "tails" of a normal distribution curve. Natural selection favors individuals nesting in trees with d.b.h.'s and heights close to the mean, and often reduces productivity of pairs nesting in trees with d.b.h.'s and heights at the minimum or maximum extremes.

If trees are too small in diameter, crowding may reduce the number of offspring that can fit in a cavity. Studies in Europe indicated that some cavity nesting species increase their clutch size with increases in nest box sizes (Karlsson and Nilsson 1977). This relationship may also exist in species nesting in natural or

Table 3.-- *Recommended numbers of snags to maintain selected densities of woodpecker populations in northeastern United States*

Species	Probable optimum d.b.h. ranges of nest trees		Optimum ranges of nest tree heights		Snags needed per 40 ha (100 acres) to maintain listed percentages of population maximums				
					Good		Fair		Poor
					100	80	60	40	20
	cm	*(in)*	*m*	*(ft)*	- - - - - - *Number* - - - - - - -				
Downy woodpecker	15-25	(6-10)	3-9	(10-30)	400	320	240	160	80
Hairy woodpecker	25-35	(10-14)	6-12	(20-40)	200	160	120	80	40
Pileated woodpecker	45-65	(18-26)	12-21	(40-70)	24	19	14	10	5
Common flicker	30-44	(12-18)	6-12	(20-40)	[1]50	40	30	20	10
Red-bellied woodpecker	36-53	(14-22)	9-15	(30-50)	270	220	160	110	55
Red-headed woodpecker	40-60	(16-24)	9-21	(30-70)	[1]200	160	120	80	40
					[2]3,330	2,660	2,000	1,330	670
Black-backed three-toed woodpecker	30-46	(12-18)	6-12	(20-40)	52	42	31	21	10
Northern three-toed woodpecker	30-40	(12-16)	6-12	(20-40)	52	42	31	21	10
Yellow-bellied sapsucker	25-35	(10-14)	6-12	(20-40)	[1]100	80	60	40	20

[1] Breeding season requirements.

[2] Wintering habitat requirements.

excavated cavities. As crowding increases, juvenile cavity nesters may kill siblings (Kilham[3]). If nest trees provided are only of minimum height, predators may seriously reduce the reproductive success of populations using such snags (Holcomb and Twiest 1968, Dennis 1969). Thus, if we provide only minimum sized snags (DBH and height) we may eliminate a species by not providing the size of nest tree that natural selection favors.

Snags provided for woodpecker species should be within the appropriate DBH and height ranges required by the species (table 3), preferably, as close as possible to the mean DBH's and heights listed in table 2. By providing the average sized snags, the probability of meeting species requirements can be maximized.

Distribution of Snags Provided

When snags are provided for cavity nesters, snag distribution must not prohibit or reduce the chance of snags being used. Thus, a uniform distribution of snags may be the best in a forest situation. This distribution optimum may not always be possible, especially during early regeneration stages of clearcuts. In such cases, a belt of "old growth" along water influence zones or a good distribution of small clumps of older trees with abundant snags within younger forest stands would be of great value to cavity nesters.

MANAGEMENT OPTIONS

One concept should dominate designs of management programs--each wildlife species has an intrinsic value in the perpetuation of natural ecosystems. Therefore, effort should be directed toward achieving or maintaining self-sustaining population levels of all native species. Many current land use patterns in eastern forests maintain structural complexity and support a correspondingly diverse avifauna. Most breeding bird species in this area have a wide geographical range, are mobile, and in no current danger of being reduced to less than a self-sustaining population. Some species, especially those that tolerate only a narrow range of habitat variability or require a specialized habitat component, need a more specialized management program. Cavity nesters fit into this category.

Four broad management options are open to the forest manager, each with its own implications to avian habitat values. These options are exploitation, even-aged management, unevenaged management and preservation. Exploitation involves no silvicultural system. The silvicultural systems which might be employed to implement the even-aged management option include shelterwood, seedtree, and clearcutting systems. The selection system--either single tree or group selection--would be used in uneven-aged management. The preservation option includes active protection of a stand or the no-management, no-use, leave alone option. These were discussed in greater detail by Zeedyk and Evans (1975). How these options might affect nongame birds are as many and as varied as the bird species and forest types involved. The preservation option probably provides the best opportunity for an abundance of snags and corresponding populations of snag-dependent species. We are not recommending the preservation option for any large area because of the other values of a well-managed forest and the negative impacts on the many bird species that require an early successional stage.

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[3] Personal communication.

For the production of high quality sawtimber and veneer trees in the oak-hickory forests, even-aged management is recommended (Sander 1977, Roach and Gingrich 1968). This objective can best be attained with clearcutting or some form of shelterwood. The time required to grow trees to a given diameter can be greatly reduced and the forest yield substantially increased if thinnings are initiated early in the life of a stand (Sander 1977). When management prescriptions call for thinning to begin at age 20 and occur at 10-year intervals, the effect on cavity-nesting species could be disastrous. Gingrich (1971) reported that at age 20 an unthinned upland hardwood stand will contain from 3,400 to 6,200 trees per hectare, and during the nest 60 years, without thinning, 90 percent of these will die. These dead and dying trees are essential habitat components for at least 26 cavity-nesting species of birds in the oak-hickory forest (Hardin and Evans 1977).

Condition of currently available forest stands and rotation age plays an important role in the management of hole nesting species. Over 50 percent of the 116 billion trees in the northeast are less than 5 cm (3 in) d.b.h. (U.S. Department of Agriculture Forest Service 1977). Nearly all of the primary cavity excavations require a snag of 23 cm (9 in) d.b.h. for their nesting hole. Only 8 percent of the hardwood trees in the northeast are 23 cm d.b.h. or larger (table 4). The situation is even worse for the softwoods of the northeast--less than 6 percent are over 23 cm (9 in) d.b.h. Out of 116 billion trees in the northeast 8 billion are 23 cm d.b.h. or greater. Observing the number of live trees per unit area provided a base for snag management considerations (table 5). This illustrates two concerns, (1) only a small percentage of the living trees are large enough to provide suitable cavity substrate and (2) in a managed forest these large trees are not likely to be left for snags.

Table 4.--*Percent of live hardwoods by d.b.h. classes in various regions*[1]

D.b.h.		North	Minnesota	Missouri
in	*cm*	- - -	*Percent*	- - -
1	2.5	[2]100	100	100
3	7.6	48	48	39
5	12.7	25	26	19
7	17.8	14	12	11
9	22.9	8	5	6
11	27.9	5	2	4
13	33.0	2	1	2
15	38.1	1	0.6	1
17	43.2	0.1	0.3	0.5
19	48.3	0.003	0.13	0.3
21	53.3	0.002	0.06	0.14

[1] Source: USDA Forest Service (1977).

[2] Percent of trees of this d.b.h. and larger.

Table 5.--*Number of live trees per 40 ha (100 acres) on commercial timberland in the northeast*[1]

D.b.h.		Live trees per 40 ha (100 acres)	
		Hardwood	:Softwood
in	*cm*	- - *Number*	- -
1	2.5	[2]49,062	19,061
3	7.6	23,453	9,741
5	12.7	12,347	4,832
7	17.8	6,726	2,306
9	22.9	3,676	1,076
11	27.9	1,997	499
13	33.0	1,099	235
15	38.1	591	112
17	43.2	316	54
19	48.3	171	26
21	53.3	93	13
29	73.7	11	1

[1] Source: USDA Forest Service (1977).

[2] Number of trees of this d.b.h. and larger.

We won't discuss the wide variety of generalized snag management options that have previously been discussed (Conner 1978, Evans 1978). The one obvious factor is that under an even-aged management system, most of the stands will be too young to provide adequate size snags; we need to protect some areas from regeneration cuts. Zeedyk and Evans (1975) recommended leaving a 0.1 ha clump of trees within each 2 ha of regeneration (0.25 acre within each 5 acres of harvest area). Although each area would be different, this would provide between 830 (site index 75) and 1,210 (site index 55) trees left standing after clearcutting per 40 ha (100 acres). For upland hardwood stands the dominant trees on site index 55, at age 80, will average about 30 cm (12 in) d.b.h., whereas the dominant trees on site index 75, at age 80, will average 45 cm (18 in) d.b.h. (Gingrich 1971).

Although additional research would be required to evaluate this management proposal, a 5 percent trade-off in timber growing space would probably provide some of the smaller cavity nesting species adequate habitat during later stages of timber regeneration. This would not be true for larger woodpeckers such as the pileated, and possibly hairy woodpeckers which require more extensive areas of continuous forest. The arrangement of these clumps could be somewhat flexible. Combining 4 of these clumps together could provide a 0.4 ha (1 ac) mature forest in each 8 ha (20 ac) of young (regenerating) timber. These islands would provide limited foraging and nesting sites immediately following clearcutting and be of value for a long period of time.

Each stand would probably have a drainage system that needed to be protected or a partially inaccessable area. These areas could also be left uncut to provide mature forest area for forest cavity nesters with large home range requirements. We recommend that an uncut area of of 20 times the stream width, not to exceed 50 m, be left on both sides of water courses. These buffer strips will provide habitat for both game and nongame species in addition to greatly reducing erosion and stream siltation. The resulting canopy cover over streams will also prevent stream warming which negatively affects desired fish species.

THE VALUE OF MATURE FORESTS AND INSECTIVOROUS BIRDS

Economic advantages of providing areas with mature forest habitat for cavity nesters may at first seem remote. However, evidence suggests that long term advantages may exist. Most cavity nesters are insectivorous and many studies have demonstrated their effectiveness in reducing populations of insect pests that attack and destroy trees (Baldwin 1958, Knight 1958, Otvos 1965, Shook and Baldwin 1970, Koplin 1972). When woodpeckers forage on insect infested trees there are secondary benefits. Typically, they chip bark off while foraging which increases the effectiveness of insects that parisitize the insects that are attacking the tree (Otvos 1965).

In order for insectivorous birds to buffer insect epidemics, they must be maintained at sufficient population densities. Providing enough snags to maintain bird populations in mature forest habitat is crucial, especially for primary excavators.

Insectivorous birds that are secondary users of nest cavities will often nest in artificial nest boxes. Providing nest boxes for such birds can increase avian population densities greatly while concurrently decreasing densities of insects (Bruns 1960, Tichy 1963, Campbell 1968). Table 1 provides nest box and entrance hole dimensions for selected species.

If insect outbreaks occur when insectivorous bird populations are at sufficient densities, the birds can concentrate in areas of outbreaks and buffer, contain, or possible eliminate the insect infestation, thus possibly reducing economic losses. Concentration of insectivorous birds at insect infestation does occur and has been documented (Blackford 1955, Yeager 1955, Morris *et al.* 1958, Koplin 1969).

Additional benefits can be derived if natural predators are used to control insect pests. Biological control may eliminate or reduce the expense, "pesticide resistance" problems, and environmental dangers of pesticide applications.

Recommendations

1. Manage for maximum feasible rotation age.
2. Consider old growth a high priority option. Select stands for deferred cutting as early as possible--age 20 is optimum.
3. Leave a 0.1 ha clump permanently uncut in each 2 ha of regeneration cut.
4. Discontinue removal of dead, dying, and decayed trees for use as materials or firewood in areas where nest cavity sites are limited.
5. Consider management techniques such as providing artificial nest boxes and boring holes in suitable sized trees when cavity availability is limited.
6. Consider leaving permanent uncut buffer strips on both sides of streams.

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APPENDIX

Wood duck- - - - - - - - - - - - - - - - -*Aix sponsa*
Common goldeneye - - - - - - -*Bucephala clangula*
Hooded merganser - - - - - *Lophodytes cucullatus*
Common merganser - - - - - - - -*Mergus merganser*
Turkey vulture - - - - - - - - - - -*Cathartes aura*
Peregrine falcon - - - - - - - -*Falco peregrinus*
Merlin - - - - - - - - - - - - - *Falco columbarius*
American kestrel - - - - - - - -*Falco sparverius*
Barn owl - - - - - - - - - - - - - - - - - *Tyto alba*
Screech owl- - - - - - - - - - - - - - - *Otus asio*
Barred owl - - - - - - - - - - - - - - *Strix varia*
Boreal owl - - - - - - - - - - - *Aegolius funereus*
Saw-whet owl - - - - - - - - - - *Aegolius acadicus*
Chimney swift- - - - - - - - - *Chaetura pelagica*
Common flicker - - - - - - - - - -*Colaptes auratus*
Pileated woodpecker- - - - - -*Dryocopus pileatus*
Red-bellied woodpecker - - -*Melanerpes carolinus*
Red-headed woodpecker-*Melanerpes erythrocephalus*
Yellow-bellied sapsucker - - -*Sphyrapicus varius*
Hairy woodpecker - - - - - - - *Picoides villosus*
Downy woodpecker - - - - - *Dendrocopus pubescens*
Black-backed three-toed- - -
woodpecker- - - - - - - - *Picoides arcticus*
Northern three-toed
woodpecker- - - - - - -*Picoides tridactylus*
Great crested flycatcher - - -*Myiarchus crinitus*
Tree swallow - - - - - - - - - *Iridoprocne bicolor*
Purple martin- - - - - - - - - - - - -*Progne subis*
Black-capped chickadee - - - -*Parus atricapillus*
Boreal chickadee - - - - - - - - -*Parus hudsonicus*
Tufted titmouse- - - - - - - - - - - *Parus bicolor*
White-breasted nuthatch- - - -*Sitta carolinensis*
Red-breasted nuthatch- - - - - -*Sitta canadensis*
Brown creeper- - - - - - - - - -*Certhia familiaris*
House wren - - - - - - - - - - - *Troglodytes aedon*
Winter wren- - - - - - - *Troglodytes troglodytes*
Eastern bluebird - - - - - - - - - - *Sialia sialis*
Prothonotary warbler - - - - *Protonotaria citrea*

RAPTOR MANAGEMENT AND REHABILITATION

Patrick T. Redig [1/]

The medical and surgical treatment of injured raptors has potential for significantly mitigating the effects of unnatural mortality among certain species, notably the Bald Eagle and Peregrine Falcon. Since 1972 over 1200 raptors have been treated in our facility, 101 of which were eagles and 15 were Peregrine Falcons. The relevance of rehabilitation as a management tool is discussed in the context of the overall status of raptor management.

The management of raptors has become a subject of considerable widespread interest only since about 1966 (Fyfe, 1976). Since then there has been a great deal of research performed, primarily through academic institutions. Such research has been only partially related to management and has most frequently been very local in geographic scope and narrow in terms of subject scope (e.g., behavior at the nest, nest site habitat, food habits during the breeding season). Fuller (1978) has made the observation that the majority of raptor field studies have been conducted on the plains of the Western United States. With the exception of a few locally studied areas such as the Bald Eagles in the Great Lakes States, and studies done in Florida, Ohio, and Pennsylvania there is a real paucity of literature pertaining to eastern raptors. These patterns possibly relate to those general difficulties of studying the thinly distributed populations of very mobile, wide ranging predators. In the eastern forest,observations (other than at nest sites), are very difficult; thus more studies have been done in open areas. The scarcity of research leaves little for the manager to work with. However, the raptors respond to the same management principles as those already researched and in use for species that have been managed for forty or more years (Hamerstrom, 1974). Thus the obvious conclusion of habitat preservation as a key item in the survival formula of raptors is easily achieved. For the practical purposes of developing management programs a breakdown into specific areas of effort within the framework of habitat preservation is necessary. Of the many approaches that may be taken, there are four facets which have been experimented with to considerable degree in the management of raptors during the 1970's and these are: 1) identification and protection of nesting sites, 2) providing and protecting uncontaminated food supplies, 3) augmenting production through providing additional nesting sites where a shortage of these is identified as a limiting factor, captive rearing and release of youngsters through fostering or hacking, and manipulation of clutches at either the egg or nestling stage, and 4) reducing mortality in the wild by identifying major causes of injury and mitigate their effects by removing the hazard where possible and by providing medical and surgical care for injured individuals so they may be again released.

It is from the latter point that I draw most of my experience having been directly involved with providing medical and surgical care to over 1200 raptors since 1972. It is the purpose of this paper to present the justification and significance of raptor rehabilitation as a management tool within the context of present day

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raptor population conditions and proposed and actual management schemes for these birds.

The reasons for managing raptors go beyond the fact that they are a wildlife resource and an important portion of the ecosystem in need of protection and conservation. Several species of North American raptors, notably the Bald Eagle, Osprey, and Peregrine Falcon have undergone precipitous declines over much of their former ranges in the last 30 years (Hickey 1969, Wetmore and Gillespie 1976). The Peregrine in particular has been completely extirpated from its range in the eastern United States and only a remnant population is left in the western United States (Fyfe _et al_. 1976). The documentation of the disappearance of the Peregrine at the international conference held in Madison, Wisconsin in 1965 contributed significantly to the awakening of this country to the problems of industrial and agricultural pollution and to the eventual banning of DDT in the early 1970's (Hickey 1969, Peakall 1976). Acting in concert with the pollution problem has been the widescale loss of habitat, a problem which has contributed heavily to the demise of the Bald Eagle over most of the 48 states. There are several other raptorial species such as the Merlin, Cooper's hawk, Red-shouldered Hawk, and the Marsh Hawk which are known to have undergone declines in certain locales and which, because of their particular food preferences or habitat requirements are particularly vulnerable to disturbances of these parameters. However, these 4 species lack the special dash and appeal of the Peregrine and Bald Eagle and therefore have not been given as much attention. The basic censusing data is not even available on these raptors to make a meaningful determination of their status over most of their range.

There is also a significant utilitarian reason for the management of raptors. Since the various species occupy niches at the tops of long and complex food chains and have specific requirements for nesting, they can be useful as environmental barometers. A healthy diversified, regularly reproducing raptor population in a given area implies that management programs directed toward forest and wildlife production are being conducted in accord with principles of maintaining a balanced ecosystem.

Because of the importance of raptors and the ecological information that can be obtained from monitoring and managing their populations, the USFWS in 1978 created a position within their ranks, that of a raptor biologist. Through this office there is the potential for efficiently directing and funding needed research on raptors,for standardizing census and survey techniques which will permit a synthesis of local situations into broader conclusions about populations, and to test and suggest management strategies. Through contractual and cooperative agreements there are many new opportunities for raptor research and management ahead.

Cade and others have pointed out previously that we know the necessary principles to implement management programs for raptors (Cade 1974). These principles include inventory of the breeding stock, reproductive rates, survival of various age classes, and determination of limiting factors, followed by scientific manipulation of these factors. However, because of the solitary nature of raptors, their position at the top of complex food chains, their relatively few numbers, and their great mobility the task of determining basic management parameters involves considerably more effort and expense than that required for many of the game species to which these techniques have been so successfully applied.

The censusing of nest sites and implementation of management programs for nest sites, the first of the four management approaches presented above has been very successfully accomplished in the case of the Bald Eagle population in the Great Lakes States. Broad scale censusing coverage of the eagles in these states (Minnesota, Wisconsin, Michigan, Ohio, Indiana, and Illinois) has been conducted since 1973 (Madsen 1977). Over 400 pairs of birds are observed regularly and it is estimated that over 90% of all active nest sites are included in the survey. Fixed-wing aircraft have been extensively used for making observations. The results of these surveys from 1973 through 1977 are included in Table 1. Based on the number of young produced and the relative constancy in the number of nest sites occupied, the eagle population in this area is certainly stable and shows a trend indicative of an increase.

Table 1.--Bald eagle breeding population and breeding success, Great Lakes States, 1973 through 1977. From Madsen, 1977.

State	1977		1976		1975		1974		1973	
	Occupied Nests	# Young	Occupied Nests	# Young	Occupied Nests	# Young	Occupied Nests	# Young	Occupied Nests	# Young
Wisconsin	151	181	146	139	111	112	109	103	108	107
Michigan	87	95	84	80	88	79	82	45	83	66
Minnesota	156	179	122	163	120	145	127	96	115	113
Ohio	4	1	5	2	5	3	6	2	7	2
Illinois	0	0	0	0	0	0	2	0	0	0
Indiana	0	0	0	0	0	0	0	0	0	0
Total	398	456	357	384	324	339	326	346	313	288

The Bald Eagles on the Chippewa Forest, a relatively small (6400 km^2) and intensely managed forest, have been studied since 1963 (Mathisen *et al*. 1977). A two-flight survey conducted in fixed-wing aircraft has been shown to provide an adequate means for detecting substantial changes in the population status of this much studied and closely monitored population (Fraser 1978). Because of the numerous studies conducted on this population of eagles, management is moving from a general approach of protecting habitat and eliminating disturbance to a specific approach involving the formulation of management plans for specific eagle territories. These specific plans take into account the tolerance of a given pair of eagles to certain types of disturbance as determined by quantitative experimentation (Stalmaster 1978), unique features of a given territory such as proximity to water, to construction work or projects involving frequent intrusion to the area for inspection or repair, and finally the potential for future alteration of the habitat by logging, dam construction, and recreational development (Mathisen *et al*. 1977).

By contrast other investigators studying Bald Eagles over much large tracts of land such as the 100,000 km^2 area surveyed by King (1972) or the 174,000 km^2 are surveyed by Grier (1977) chose to randomly sample their areas and make inferences about the population status and trends on that basis. Because of the differences that exist among various eagle populations with respect to habitat type and usage, and levels of human activity within eagle territories, the point has been made that for successful comparison of the results of various studies, what is needed is not complete standardization of field procedures or analytical techniques, but rather standardization of the parameters being measured (Fraser 1978).

The integration of forestry management policies with the requirements for successful and stabilized eagle production on the Chippewa National Forest are now well established. The Minnesota Department of Natural Resources with cooperation from the U.S. Fish and Wildlife Service is about to implement a management plan for eagles not nesting on public lands under federal jurisdiction. There are 44 known nesting sites of Bald Eagles outside of national forests in Minnesota (Henderson, personal communication, 1978). Land ownership status of these nest will be determined and management implemented on a recommendation basis utilizing practices that have proven to be efficacious on the Chippewa.

Specific nest site identification and protection is a useful approach for species such as the eagle where the nest is located in unique places and is frequently reused. The cliff nesting raptors such as the Peregrine Falcon and the Prairie Falcon also have readily recognized and frequently reused nest sites which would render them amenable to management programs similar to those developed for nest site protection of the eagle. For most other species of raptors, nest sites are decidedly more ephemeral and the unique common feature of sites are not as readily recognized. However, recent research on Broad-winged Hawk nest site selection (Kerans 1978) and Marsh Hawk nest site selection (Hamerstrom 1976) has shown that indeed there are some unique features sought by these birds which can be defined by continued research. Kerans (1978) concluded that in the case of the Broad-winged Hawk, the current 40 year cycle on which white-tailed deer and ruffed grouse management was based would indefinitely provide adequate nesting habitat for this species.

Of course considerations must go beyond simply the nest site and take into account the need of the parent birds for hunting, roosting, and freedom of conflict with other species of raptors. A radiotelemetry study recently completed at the Cedar Creek Natural History Area in East Central Minnesota (Fuller 1979) provides data on the spatial and temporal partitioning of woodland habitat by resident raptors, providing forest managers with yet another set of parameters to place in their management equation.

Another approach toward eagle management in the Upper Mississippi region is that of protecting wintering roost sites. A private organization, the Eagle Valley Environmentalists, has been the main promoter and executor of this concept since 1972. Their approach has been to identify sites where large numbers of eagles roost at night and raise money to buy the land on which these sites are located, or enter into easement agreements with landowners to insure preservation of the roost site on a long term basis. Without downplaying the importance of wintering habitat for eagles, other investigators have advised caution in the large scale outlay of public and private money to buy eagle roost sites outright since the occupancy of these sites is affected by local annual variations in weather and food availability (Grier 1977).

The second approach to raptor management for which there are some programs currently implemented is that of insuring uncontaminated food supplies. Whereas toxicity to raptors due to the food chain transfer of agricultural pesticides and industrial pollutants has been well established as in the case of the Peregrine Falcon, the hazard of secondary toxicity from lead pellets ingested with the flesh of prey species has only recently been recognized (Locke 1969, Mulhern _et al_. 1970). Locke (personal communication 1978) has autopsied 15 Bald Eagles in which secondary lead poisoning was suspected and later confirmed in nine of them. This author has seen secondary lead poisoning in 3 Prairie Falcons, 1 Goshawk, and 1 Bald Eagle. Among raptors the Bald Eagle is particularly vulnerable to secondary lead poisoning since they frequently scavenge on crippled ducks and geese during and after the waterfowl season. It is believed that toxicity occurs because of a failure of the pellet casting mechanism to cause expulsion of the pellets. Studies are currently underway at the University of Wisconsin (Temple and Friend) and at the University of Minnesota (Hennes, Frenzel, Duke, Redig, and Henderson) to assess the magnitude of secondary lead poisoning in eagles. It is likely that management decisions affecting the use of lead shot in certain waterfowl hunting areas will be forth coming based on this research.

The continued pesticide contamination of arctic Peregrine Falcons is an example of a food contamination problem for which the implementation of remedial management is not immediately possible. These birds are highly migratory and many pass along the Gulf Coast of Texas each year enroute to wintering areas in Central and South America (Rogers & Hunt 1975). It appears that the very heavy utilization of DDT in these countries is the source of contamination for these birds and their migratory food supplies (Burnham 1978). It has been suggested by resolution at the Raptor Research Foundation in 1976 that chemical pesticides deemed unsuitable for use in the United States not be allowed export abroad by American manufacturers.

Another management scheme that has been proposed for these arctic Peregrines to protect them from heavily contaminated prey is shortstopping (Cade 1974). Migrant Peregrines on southward passage would be trapped, held over the winter by qualified individuals, and released in following springs at 1,2, or 3 years of age to migrate back to the tundra free of pesticide loads. To date this idea has not been implemented.

The third approach to raptor management, that of augmenting production, has taken several forms. The various methods have included transferring healthy eggs or young birds from successful nests to active sites with a history of repeated failure (Madsen 1977,Burnham.1978), encouraging multiple clutching to occur by removal and artificial incubation of the first set of eggs (Cade 1974, Burnham 1978), captive production of birds and subsequent release into the wild by fostering them into remaining active wild nests or by controlled reintroduction where no wild birds exist (Fyfe 1976, Sherrod and Cade 1978). Increasing the number of available nest sites has been done for Ospreys (Ames & Mersereau 1964, Postupalsky 1974) for Prairie Falcons (Olendorff & Stoddard 1974), for Red-tailed hawks and Great-horned Owls (Grewe 1976), and for Kestrels (Hammerstrom 1974). The specifics of two cases of augmentation are illustrative.

Several Bald Eagle nests along the east coast of Maine had a history of reproductive failure spanning 10-12 years due to heavy pollutant contamination of the adults. A scheme requiring the transfer of healthy partially incubated eggs from Minnesota and Wisconsin nests was proposed. The first Bald Eagle egg transplant was conducted in 1974. Three eggs, comprising two complete clutches, were taken from two nests in Minnesota after 21 to 26 days of incubation. One egg was accidentally destroyed during placement in an active nest. The remaining two eggs were placed in separate unproductive nests in Maine. One addled egg found in each of the two Maine nests was removed at the time of the transplant. Both Minnesota eggs hatched under the foster parents. One eaglet disappeared after 10 days and one successfully fledged. Single dummy eggs were placed in the two Minnesota nests at the time their eggs were taken to hold the birds on their territories. One pair incubated the dummy eggs 10 days before deserting, while the other pair immediately abandoned the nest site. These nests were not reoccupied in 1974, nor were the same nest sites used in 1975 and 1976. It is not known if the donor pairs used alternate sites. In Maine, neither of the 1974 recipient nests was reused in 1975; one was reused in 1976. An alternate nest was used by one pair in 1975 but the other pair is not believed to have utilized an alternate nest. In sum, in 1974 three eggs were removed from two nests in Minnesota and one eaglet was successfully fledged in Maine.

In 1975, the second Bald Eagle egg transplant was conducted. Four eggs were taken from two nests in Wisconsin. One egg was placed into each of four nests in Maine. One egg was not accepted by the foster parents. Of the three eggs incubated, two hatched and one eaglet fledged. Five of six eggs and shell fragments of a seventh egg found in the four Maine nests were removed at the time of transplant. There were 39 active nests located in Maine in 1976 and six to ten were candidates for transplanted eggs. Although still active, the candidate nests had at least a five year history of failure. These nests were located along the Atlantic Coast, Penobscot River drainage, and Moosehead Lake. Eight Bald Eagle eggs were transplanted from two nests in Wisconsin and two nests in Minnesota. Of the eight eggs taken from the lake states, two eaglets fledged (Madsen 1976).

The Peregrine Falcon has been the subject of a large scale breeding and release program conducted in the United States by the Peregrine Fund at Cornell University (Sherrod and Cade 1978) and by the Canadian Wildlife Service in Alberta, Canada (Fyfe 1976). At Cornell from 1970 through 1977, 229 falcons have been produced of which 133 were released by various methods between 1974 and 1977. In 1976 and 1977 a few of these released birds were observed returning to their release sites and there is one known instance where a captively reared female has paired with a wild male and produced offspring (Cade 1977). Grier (1976) estimated that, based on regular rates of production and mortality for healthy peregrine populations, the release of 250 falcons per year for 15 years would be required to re-establish the Peregrine east of the Mississippi River to approximation of its former level. The results of the captive rearing program have so far been very encouraging, but it will be a few more years before any reliable forecasts of the eventual outcome can be made.

The last of the four management approaches to be discussed is that of reducing mortality. The primary thrust in this regard has been the grass roots development of a large number of so-called raptor rehabilitation programs across the country over the last eight to ten years. A survey was conducted during the summer of 1978 to document the magnitude of raptor rehabilitation in the United States (Duke, Clarke, and Redig). 500 questionnaires were mailed out to individuals who had now or at one time held a federal permit for tending to injured raptors or had otherwise expressed an active interest in the subject; 202 replies were received. A 3 years total of 5,329 raptors of 39 species was reported. Since there are a sizeable number of raptors being submitted to these programs, examination of the reasons for admission of injured birds could reveal some of the signficant causes of injury and mortality among raptors. This type of information as well as success rates were sought by the original questionnaire; however, due to many inconsistances in record keeping among respondents, the information is not presently too significant. A standardized record keeping and summary form is now being drafted for use by all persons holding rehabilitation permits and will be distributed through the Raptor Information Center.

The records from our own program do provide an insight into the numbers and types of injuries incurred by raptors in this region and the type of success that can be realized from a rehabilitation effort. Table 2 is a list and a tally of the raptors we have handled at the University of Minnesota from April 1, 1972 through December 31, 1978. Table 3 is a summary of the problem categories for which these birds listed in Table 2 were submitted. Table 4 is a specific breakdown of problem categories for Eagles and Peregrine Falcons for 1977.

Approximately 75% of the raptors handled were presented for traumatic injuries; in most instances there were fractures of one or more of the long bones. In recent years techniques have been described for the anesthesia of raptors (Redig and Duke 1976, Paddleford 1978) and for the reduction and fixation of fractures of the long bones of raptors (Redig and Rausch 1978). The degree of success achieved in the repair of fractures and other injuries has depended upon which bone was broken, the duration of time since the injury, the severity, and the cause. Prognostic evaluations can be made only by a clinician with experience in handling avian fractures. Rehabilitation goes far beyond caring for the obvious fracture or injury, requiring expenditure of time, effort, and expertise in providing adequate housing, nutrition, and vigilance against the development of other diseases and problems to which raptors are susceptible.

The category that has proven to be the most difficult to handle is trap-induced injuries. In any given year these injuries comprise about 16-20% of our admissions and have the lowest chance for successful repair. Table 5 is a cumulative listing through 1977 of all raptors admitted with trap injuries. Table 6 is a specific listing of trapped eagles. Only 3 out of 15 trapped eagles were released and these were all partial amputees. Most of the trapping incidents involved eagles caught in open-baited traps set for furbearing animals during the winter. Trapped limbs freeze quickly and there is no chance for rejuvenation of frozen tissue. However, we have several instances on record where the limb did not freeze but the impact of the trap caused sufficient soft tissue damage to lead to vascular destruction and subsequent loss of the limb below the injury site some 10-14 days after the injury. Because of these types of findings, I take exception to the investigators who recently reported raptors caught in traps in the conduct of turkey predation study could be released if damage was confined only to bleeding at the trap injury site or only one broken leg (Beasom 1974).
Another sequelae observed in birds with trap or frostbite injuries is the development of vegetative and septic endocarditis, that is bacterial colonization of the heart valves following the introduction of organisms at the wound site with embolic transfer via the blood stream to the heart and occasionally the brain, (Wallach and Fleig 1969, Angrist et al. 1960, Redig 1978). The subsequent potential for cardiac malfunction is sure to shorten the life span of the animal. It would seem that this trapping problem could be managed by restricting the use of open bait sets and by educating the trapping public to the hazards their activities may have for non-target wildlife.

Table 2.--Species and numbers of raptors admitted for treatment at the University of Minnesota from April, 1972 through December 31, 1978.

Red-tailed Hawk	238	Goshawk	40	Screech Owl	58
Red-shouldered Hawk	15	Merlin	2	Burrowing Owl	1
Broadwinged Hawk	101	Kestrel	149	Saw Whet Owl	18
Swainson's Hawk	6	Prairie Falcon	29	Boreal Owl	1
Ferruginous Hawk	6	Peregrine Falcon	15	Barred Owl	58
Rough-legged Hawk	52	Gyrfalcon	5	Great-Gray Owl	3
Harris' Hawk	1	Bald Eagle	101	Long-eared Owl	27
Marsh Hawk	13	Golden Eagle	20	Short-eared Owl	20
Sharp-Shinned Hawk	20	Osprey	16	Snowy Owl	24
Cooper's Hawk	16	Turkey Vulture	5	Great Horned Owl	215

TOTAL 1,275

Table 3. Summary of causes of injuries to raptors submitted to the University of Minnesota.

Injury	1972-1974	1975	1976	1977	1978	Overall
Projectile	34	35	23	16	13	24
Traps	25	12	8	7	4	11
Accident	22	30	37	46	49	37
Disease	8	5	12	8	2	7
Orphaned	3	10	15	12	14	11
Other	8	8	5	10	18	10

Table 4. Breakdown of problem types for which Eagles & Peregrine Falcons were submitted in 1977.

	Eagles		
	Bald	Golden	Peregrines
Projectile	6	5	1
Trap	3	1	
Accident	7	1	2
Starvation	2		
Orphan	5		
Other	3		

Table 5. Listing of all raptors submitted for treatment of trap-induced injuries, other than pole traps.

Species	Year/Number				
	1974*	1975	1976	1977	Total
Great Horned Owl	5	5	9	5	24
Snowy	1			1	2
Barred Owl		2			2
Screech Owl	1				1
Red-tail		9		3	12
Rough-legs	1	1	1	3	6
Marsh Hawk			1		1
Broadwing				1	1
Kestrels		1			1
Bald Eagles	2	1	1	6	10
Golden Eagles	1		1		
Totals	11	19	13	19	62

*Records prior to 1974 are inaccurate except for eagles.

Table 6. Listing of Bald and Golden Eagles submitted for treatment of trap-induced injuries. From Redig (1978).

	Clinic #	Locale of Origin	Fate
1973	1	Paynesville, MN	Released after amputation of DII
	2	Hastings, MN	Released after amputation of DIII
	3	Brainerd, MN	Died
1974	A-4	Benson, MN	DOA
	A-75	Detroit Lakes, MN	Died after surgery to repair fracture
(Golden)	A-105	Fergus Falls, MN	Died
1975	B-129	Michigan	Held as a 1-footed cripple
1976	C-193	Fergus Falls, MN	Died after foot was lost
(Golden)	C-203	Illinois	Died
1977	D-29	Rhinelander, WI	Foot amputated-bird died later
	D-206	Michigan	Foot amputated locally-DOA
	D-271	S. Dakota	Both feet destroyed-bird died
	D-274	Fergus Falls, MN	Released with slight damage to DIII
	D-298	Ely, MN	Halux destroyed-bird crippled
	D-306	Alexandria, MN	Both feet destroyed-bird died

Total # of trapped eagles died - 10
Total # of trapped eagles crippled - 2
Total # of trapped eagles released - 3

Another subtle problem whose actual statistics are buried in the "accident" category is that of raptor collisions with power lines. Nelson (1978) and Crawford et al. (1974) have documented the electrocution of raptors by power lines and suggested management remedies. The injuries referred to here are not electrocutions, but simple collisions resulting in fracture of the wings usually. Fitzner (1975) briefly described this hazard for owls. In 1978 alone our program has received 2 Bald Ealges, 2 Ospreys, 1 Golden Eagle, 1 Broad-winged Hawk and 1 Peregrine Falcon which were injured by flying into wires. In all cases the injured birds were found adjacent to high tension power lines and no other cause of injury was found upon examination. One Osprey was admitted with a fractured coracoid; all others received fractures to the wing bones proper. The significance of this type of injury in light of the many other means by which much larger numbers of birds are destroyed may be questioned, nevertheless, the birds do hit wires and there are more and more high tension lines being strung completely across Minnesota and elsewhere. It is conceivable that these lines could have some significant effects on local populations of raptors.

One of the measures of success of such a program is the disposition of the birds treated. Table 7 is a summary of our attempts through 1977 and Table 8 is a specific summary of the disposition of Eagles and Peregrine Falcons (Redig 1978). Of even more significance is the survivability of rehabilitated raptors after they are released. Approximately 500 raptors have been released from this program with all birds bearing conventional USFWS bands. So far returns have been reported on 5 of these birds with survival rates ranging from 2 weeks to 4 months. More useful information has been obtained from a color marking scheme employed for Bald and Golden Eagles in addition to banding. Of 28 eagles marked with vinyl wing markers, subsequent sitings have been made on 8 birds. Two of these birds were released on the Swan Lake Refuge in Missouri in 1976 (Griffin and Redig) and their progress followed through February when the mass of wintering eagles departed the refuge. Another young eagle released at the Montezuma Wildlife Refuge in Upstate New York in early September was followed for 6 weeks before it became entangled in barbed wire and died. Postmortem examination of this bird revealed that it was in a good nutritional state. Another adult eagle marked and released on 3/19/76 was reported during the spring of 1978 to be occupying a nest with young eagles near Harris, Minnesota. And another adult released on 12/28/73 was found in June, 1974 by Chuck Sindelar at a Wisconsin nest with 2 young in the nest. One last example is an eagle originally shot near Oshkosh, Wisconsin on 6/8/76, banded and released on 9/4/76 at Duluth, and seen

Table 7. Summary of rehabilitation attempts for all species of raptors (Percentages in each year). From Redig (1978).

	1975	1976	1977	Overall
Died	30	22	15	22
Destroyed	3	8	11	7
Holding	8	13	9	10
Research	16	15	10	14
Successfully Rehabilitated	43	43	39	42
Pending*	0	0	16	5

* Indicates raptors not ready for release at end of the year, but for whom complete recovery is anticipated.

Table 8. Disposition of eagles and peregrines (Percentages in each year). From Redig (1978).

	1972-1974	1975	1976	1977	Overall
Died	47	27	41	18	33
Holding	0	7	0	11	3
Research	26	13	18	19	19
Successfully Rehabilitated	27	53	31	26	37
Pending	0	0	0	26	8

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again on 9/5/76 3 miles north of the release site and again in mid-January on the Swan Lake Refuge in Missouri.

During the spring of 1978, 5 nestling Bald Eagles were brought in at various times after they had been blown from their nests during storms. 3 of these birds were admitted with leg fractures. Approximate age of the birds at the time of admission ranged from 3 weeks to 12 weeks. The two uninjured birds were given physical examinations, held for a week of observation, and then fostered back to other 1 chick eagle nests. One of these birds was approximately 4 weeks old and the other 12-13 (nearly fledged) at the time fostering was done. No serious aggression with other eagle chicks or problems with adult acceptance were observed during subsequent observations. Of the other 3 chicks, one had fractures in both legs and convalescence was not complete until mid-September. He was not released, but rather placed in a captive breeding project. Both of the other birds underwent surgical repair of their tibio-tarsal fractures and completed convalescence before the end of the eagle nesting season. One bird was put back in a nest near Drummond, Wisconsin on July 1, 1978. There was a single chick in the nest about 2 weeks younger than the rehabilitated bird. There was momentary aggression between the two chicks manifested by threat postures, but no contact. Ground checks made on July 3,4, & 5th revealed only one bird in the nest; on July 6th, 2 chicks were seen sitting on the edge of the nest.

The remaining rehabilitated bird was taken to a nest near Minong, Wisconsin on July 15, 1978. Again there was 1 chick, nearly ready to fledge in the nest. The new bird was placed in a dead snag 30 m from the nest tree and about 5 m off the ground. No observations were made until July 20th at which time 1 chick of uncertain identity was seen in the nest and 1 adult in the nest tree. On July 28th the color marked youngster was observed in a tree about 200 yards from the nest tree. The unmarked youngster was not seen at that time.

Color marking of rehabilitated eagles clearly yields much more information concerning the post-release survival of these birds. The limited data available so far indicates that in fact these birds will survive and even resume apparently normal patterns of migration and reproduction. Because the post release survivability of rehabilitated birds is important information to have, the time is right for a program of radio tracking of these birds following release to learn more about their reintroduction into the wild.

Clearly, rehabilitation of raptors provides two avenues of direct benefit to the resource, 1) the accumulation of data regarding the causes of raptor injury and mortality on both a regional and national level, and 2) the return of a significant number of individual birds, particularly eagles, to the wild.

By expanding the scale of these operations there is the potential for the recovery of many more raptors. The magnitude of the beneficial effects can be enhanced by promoting centralization of efforts so that there is increased continuity in the learning from old mistakes and application of new techniques and by increasing the level of funds available for this work.

There are also signficant indirect effects that are realized from the project underway at the University of Minnesota. By conducting this work at a veterinary college within a major university, the opportunity is presented to teach concepts and techniques of avian research and medicine to veterinarians and wildlife students who in turn can relate this information to many other people throughout their careers. Crippled birds, unsuited for release are available for use by students and researchers to conduct controlled laboratory testing of hypotheses that can lend significant insight into field observations. Utilization of injured raptors for research in behavior, medicine, surgery, pathology, toxicology and other fields, is possibly the single most important aspect of any rehabilitation project. Such research is a source of new information that will be used in the years to come to provide improved methods for the management of raptors in the laboratory and in the field (Redig 1978).

Lastly, there is a significant benefit to be realized by utilizing material depicting the plight of injured raptors to sensitize the members of the public to the need for raptor and wildlife conservation. Photographs, X-rays, and crippled live specimens can create lasting impressions on the minds of people who wouldn't otherwise be concerned about injured raptors. By increasing the levels of awareness and appreciation for raptors and wildlife among the public, it is hoped that not only the direct mortality-causing effects of human activity, such as shooting and trapping, may be reduced, but also the indirect effects of habitat destruction may be realized and mitigated.

If the whole matter of raptor management appears thin and shallow at this point the reason is likely to be related to the recency of its application. Prior to the mid 1960's, most raptor management was directed toward their destruction; research primarily documented declines in populations for select species. The first significant attempts at management were seen directed toward the Bald Eagle in the mid-to-late 60's, followed by augmentation efforts to save the Peregrine in the early 70's, which efforts have yet to prove their management potential. Reducing mortality by removing hazards and repairing injured raptors is similarly only recently being developed and has yet to be proven a significant tool in the overall scheme. Certainly this multifaceted approach provides a much brighter future for the raptors than was thought possible 10 years ago, but the work is just barely started.

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COMPILATION OF AVIAN INFORMATION IN COMPUTERIZED DATA STORAGE AND RETRIEVAL SYSTEMS OF THE NORTH-CENTRAL AND NORTHEASTERN UNITED STATES

Thomas W. Hoekstra and Charles T. Cushwa[1/]

Abstract.--Characteristics of 18 computerized files of bird information in the North Central and Northeast United States were compiled. Information contained in the files included species occurrence, population and management requirements. No standard framework for data files was identified from the 18 custom built systems. Expected expansion and development of new systems necessitates improved communication to establish standard definitions for identifying, describing and coding data elements.

INTRODUCTION

Many computerized data/information systems are currently in use or being developed to store and retrieve information about nongame species of birds. We were asked to review and summarize systems with data from the North Central and Northeastern part of the United States. Our review is cursory. To provide a brief overview on this subject, we called system managers and others, asking a series of questions about their system. In this report we have categorized information available by species occurrence, populations, and management requirements. We suggest individuals identified in the Appendix be contacted directly for detailed information about systems. We apologize for those systems we inadvertently overlooked. The assistance of Mr. Ralph Alig in preparation of this report is deeply appreciated.

CHARACTERIZATION OF DATA STORAGE AND RETRIEVAL SYSTEMS

We identified 18 computerized files which contain some information about birds in the N.E./N.C. part of the United States (Table 1). Approximately one-third of the files contain a list of all categories of birds (Table 1). Species lists for waterfowl, shorebirds, upland gamebirds, raptors and migratory birds are available from approximately two-thirds of the files. Passerine, non-migratory, and seabird species lists were included in nearly half of the files.

Fifteen files have data at the state level. Less than half of the files have species lists at the regional level. Species lists for political units smaller than the state are available from about one-third of the files. A continental United States list was found in eight files.

Fourteen files contain information about categories of birds associated with various vegetation types. Twelve files produce a link by ecosystem (combinations of vegetation types). Five of the files will provide a species list by the following ecological categories: biome, ecosystem, vegetation type, stage of succession, community structure and specialized habitat such as cavities, snags, riparian, etc.

Population Estimates

Fourteen files have population estimates or population trends for some category of birds (Table 2). Population estimates are available in nine information bases. Waterfowl are the most common category of birds for which we have population estimates. No population information is computerized for passerine bird populations except for species that

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are threatened or endangered. The State is the most common unit of political organization for population data. Continent-wide population estimates are not available. The biome and ecosystem level of ecological organization for population estimates are represented in the most information bases.

Population trends for gamebirds are best represented; however, two information bases contain trend information for passerine birds. Specialized habitats are the lowest ecological level represented and are present in four of the information bases.

Compared to species occurrence information, population estimates or trends are both difficult and expensive kinds of information to obtain for data systems. The number of systems containing these types of information reflect this fact.

Management Requirements

Six files have some population management information defined by protection or harvest quotas (Table 3).

Habitat requirements of bird species can be effectively used in developing habitat management programs and are the most common management type of information available from computerized data storage and retrieval systems (Table 3). Ten of the information bases contain species habitat requirements. Compared to other kinds of information for non-game birds, they are well represented in data systems by information on habitat requirements. Habitat management guidelines are most available for game species; however, management guidelines for non-game bird habitat occur in four files.

"How Much of What They Require is Available?"

Effective evaluation of alternative management practices and mitigation require a measure of habitat tradeoffs. Quantities of available habitat in units of land area are a useful measure in analyzing the consequences of changing habitats. Seven files contain estimates of habitat quantities. Several other wildlife files have defined species habitat requirements which permit a link to data files which contain estimates of habitat quantities.

SUMMARY

Computerized files containing information about birds in the Northeastern and North Central United States are varied. The 18 files reviewed were custom built and programmed; there is no standard framework. The 1979 RPA Wildlife and Fish Assessment data base is the only file which contains information on the habitat requirements of all categories of birds in all states, territories and possessions of the United States.

Increased use of automated systems for storing and retrieving information on sensitive or threatened and endangered species is noticeable. Many data base managers contacted in this study indicated they were hoping to expand their data files or develop new ones. Several individuals interviewed said population estimates or trends will be increasingly computerized. Desired population sizes are another area of noticeable potential expansion and improvement.

Management guidelines seem to be drawn mostly from literature searches and are not frequently stored or accessed in the computer. Habitat requirements are also largely drawn from the literature, but more easily lend themselves to computerized storage and retrieval systems. The reason for the difference is the more general applicability of habitat requirement information and various ecological situations compared to management guideline information.

The emphasis of avian information in automated systems has been placed on game or threatened and endangered species, with non-game categories being less developed. There is a lack of communication between system developers and/or users with similar personnel in other regions or states.

A major recommendation is to form a data standards group for the region and attempt to use standard definitions in collecting information about birds.

Table 1.---Availability (X) of Bird Species lists in the Northeastern and North Central United States from Computerized data storage and retrieval systems

Type of Information	System Acronym or Identification Key																	
	USDI/BBS	USDI/BBC	USDI/CMBD	USDI/RUN WILD EAST	USDI/MBMO	CORNELL/ IFIF	CORNELL/ Nest	DOD/SWIS1/	U. of MN.	USDI/M. Dove	USDI/W - Cock	U. of Maine	ME/MIDAS	CAR. MUS./ Band	NY/B.W.	NAT. CONS./ LCDSF	USDA/WAFA	MD/MAGI
Category of Birds																		
Waterfowl	X	X	X	X	X		X	X					X	X		X	X	X
Shorebirds	X	X	X	X		X	X	X						X		X	X	X
Upland Gamebirds				X			X	X	X	X	X		X	X	X	X	X	X
Passerine	X	X		X			X	X						X		X	X	X
Migratory	X	X	X	X	X	X	X	X					X	X		X	X	X
Nonmigratory	X	X		X		X	X	X						X		X	X	X
Raptors	X			X			X	X	X			X	X	X		X	X	X
Seabirds			X				X	X				X	X	X		X	X	X
Political Units																		
Continental U.S.	X	X	X			X	X							X		X	X	
Region	X	X	X		X	X	X									X	X	
State	X	X	X	X	X	X	X	X		X	X		X	X		X	X	X
County				X		X		X					X	X		X		X
Township						X						X	X	X		X		X
Other 2/									X	X		X	X		X	X		X
Ecological Units																		
Biome	X	X	X		X	X		X					X			X		X
Ecosystem	X	X	X		X	X	X	X				X	X			X	X	X
Vegetation Type	X	X	X	X	X	X	X	X	X	X			X			X	X	X
Seral Stage						X	X	X					X			X	X	X
Community Structure		X	X			X	X	X					X			X		X
Specialized Habitats		X	X	X		X	X	X				X	X			X	X	X

1/ System includes information about birds classified by the F&WS as threatened or endangered of extinction.

2/ Includes a research area, physiographic regions, wildlife management units, F&WS-numbered islands, New York's thousand square kilometer inventory blocks, USGS geological quads, and Maryland's state inventory blocks (≃100 acres each)

Table 2.---Availability of estimates (E) and trends (T) in bird populations in northeastern and northcentral United States from computerized data storage and retrieval systems

Type of Information	USDI/BBS	USDI/BBC	USDI/CMBD	USDI/RUN WILD EAST	USDI/MBMO	CORNELL/ IFIF	CORNELL/ Nest	DOD/SWIS	U. of Minn.	USDI/M. Dove	USDI/W - Cock	U. of Maine	ME/MIDAS	CAR. MUS./ Band	NY/B.W.	NAT. CONS. LCDSF	USDA/WAFA	MD/MAGI
Category of Birds																		
Waterfowl	T		E	T	E			E					E				E,T	E
Shorebirds	T		E	T		E		E										E
Upland Gamebirds				T				E	E	T	T		E		T		E,T	E
Passerine	T			T	E			E										E
Migratory	T					E		E					E					E
Nonmigratory	T					E		E										E
Raptors								E	E			E	E					E
Seabirds			E					E				E						E
Political Units																		
Continental U.S.	T																	
Region	T		E		E	E												
State	T		E	T	E	E					T	E	E				E,T	E
County			E			E							E					E
Township			E			E						E	E					E
Other 1/									E	T		E	E		E			E
Ecological Units																		
Biome	T		E		E			E					E					E
Ecosystem	T		E		E							E	E					E
Vegetation Type	T		E		E					T			E					E
Seral Stage			E										E					E
Community Structure			E										E					E
Specialized Habitats			E									E	E					E
Non-ecological Units																		

System Acronym or Identification Key

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[1] Includes a research area, wildlife management units, physiographic region, F&WS-numbered islands, and New York and Maryland inventory blocks.

Table 3.---Availability of Management information for Bird species in Northeastern and Northcentral United States from computerized data storage and retrieval systems

	System Acronym or Identification Key																
Management Information Category of Birds	USDI/BBS	USDI/BBC	USDI/CMBD	USDI/RUN WILD EAST	USDI/MBMO	CORNELL/ IFIF	CORNELL/ Nest	DOD/SWIS	U. of Minn.	USDI/M. Dove	USDI/W - Cock	U. of Maine	ME/MIDAS	CAR. MUS./ Band	NY/B.W.	NAT. CONS./ LCDSF	USDA/WAFA	MD/MAGI
Desired Population Size (H, P)[1]																		
Waterfowl				H	H			P					P					
Shorebirds				H				P										
Upland Gamebirds				H				P					P		H			
Passerine				P	E			P										
Migratory								P					P					
Nonmigratory								P										
Raptors				P				P				P	P					
Seabirds			E					P				P	P					
Habitat Requirements (F, B, S)[2]																		
Waterfowl		B,S	F,B, S	F,B				F,B, S					F,B, S			F,B, S	F,B, S	F,B, S
Shorebirds		B,S	F,B, S	F,B		B,S		F,B, S								F,B, S	F,B, S	F,B, S
Upland Gamebirds				F,B				F,B, S					F,B, S			F,B, S	F,B, S	F,B, S
Passerine		B,S		F,B				F,B, S								F,B, S	F,B, S	F,B, S
Migratory		B,S	F,B, S			B,S		F,B, S					F,B, S			F,B, S	F,B, S	F,B, S
Nonmigratory		B,S				B,S		F,B, S								F,B, S	F,B, S	F,B, S
Raptors				F,B				F,B, S				F,B, S	F,B, S			F,B, S	F,B, S	F,B, S
Seabirds								F,B, S				B,S	F,B, S			F,B, S	F,B, S	F,B, S
Habitat Management Guidelines (F, B, S)[2]																		
Waterfowl		B,S	F,B, S	F,B				F,B, S										
Shorebirds		B,S,	F,B, S	F,B				F,B, S										
Upland Gamebirds				F,B				F,B, S										
Passerine		B,S		F,B				F,B, S										
Migratory		B,S,	F,B, S					F,B, S										
Nonmigratory		B,S						F,B, S										
Raptors				F,B				F,B, S				B						
Seabirds								F,B, S				B						

[1] H = Harvest Regulation, P = Protection Regulation.

[2] F = Feeding, B = Breeding, S = Seasonal.

APPENDIX

System Acronym or Key	Name of Contact Individual and Address	System Is Available for Transport to Other Computer Centers	Computer Language	Type of Computer and Model	Data Can Be Obtained Through	Fee for data on the system, if any	Input Mode	Output Mode	Location of Computer Facility
USDI/ BBS	Danny Bystrak Migratory Bird and Habitat Lab Patuxent Research Center USDI Fish and Wildlife Service Laurel, MD 20810	no	FORTRAN	IBM 370-150	Bystrak	none for reasonable requests	cards, tape, disc	printer	Patuxent Research Center USDI Fish and Wildlife Service Laurel, Maryland
USDI/ BBC	Chandler Robbins Patuxent Research Center USDI Fish and Wildlife Service Laurel, MD 20810	no	FORTRAN	IBM 370-150	Robbins	none for reasonable requests	tape, disc	printer	Patuxent Research Center USDI Fish and Wildlife Service Laurel, Maryland
USDI/ CMBD	Stanley Anderson Patuxent Research Center USDI Fish and Wildlife Service Laurel, MD 20810	yes	FORTRAN	IBM 360-60	Anderson	none for reasonable requests	inter-active	inter-active	Interior Bldg. Washington, D.C.
USDI/ RUN/WILD EAST	Douglas Gladwin Eastern Energy & Land Use Group Harpers Ferry Center Harpers Ferry, WV 25425	yes	FORTRAN	Univac 1108	Edgar Pash EELUG Harpers Ferry Ctr Harpers Ferry, WV	tape cost ($12.00)	cards	inter-active	Arizona State University Tempe, Arizona
USDI/ MBMO	Richard Pospahala Migratory Bird Management Office USDI Fish and Wildlife Service Laurel, MD 20810	yes	COBOL	IBM 370-115	Pospahala	none, for reasonable requests	cards, tape	printer	Patuxent Research Center USDI Fish and Wildlife Service Laurel, Maryland
Cornell/ IFIF	Donald McCrimmon Laboratory of Ornithology Cornell University Ithaca, NY 14850	yes	FORTRAN	IBM 370-168	McCrimmon or the Cornell Univ. Comp. Ctr.	yes, fee schedule depends on volume used	cards, tape	cards, tape printer	Cornell Univ. Ithaca, New York
Cornell/ Nest	Donald McCrimmon Laboratory of Orinthology Cornell University Ithaca, NY 14850	yes	FORTRAN	IBM 370-168	McCrimmon or Cornell Univ. Comp. Ctr.	Same as above	cards	cards, tape printer	Cornell Univ. Ithaca, New York
DOD/ SWIS	Tony Rekas Corps of Engineers Vicksburg, MS 39180	possibly	FORTRAN	GE 635	Rekas	none	inter-active	printer inter-active	Corps of Engineers Vicksburg, Mississippi
NY/ B.W.	William Sarbello Biometrics Unit Wildlife Resources Center Bureau of Wildlife DN. of Fish and Wildlife Delmar, NY 12054	no	FORTRAN and COBOL	Honeywell 60-60	Sarbello	none at present	cards tape disc inter-active	cards tape printer	Empire State Plaza Albany, New York
Nat. Cons./ LCDSF	Helmut Moyseenko The Nature Conservancy Suite 800 1800 N. Kent Street Arlington, VA 22209	yes	FORTRAN	IBM 360-65	Moyseenko	yes, at cost	cards tape disc	printer inter-active	American Management Systems Lynn Street Arlington, Virginia
USDA/ WAFA	Thomas Hoekstra Research Wildlife Biologist RM Forest and Range Exp. Stn. USDA Forest Service 3825 E. Mulberry Fort Collins, CO 80526	yes	FORTRAN	Univac 1100-42	Hoekstra, Forest Service regional staff biologists, or Dennis Schweitzer, USDA FS, WO	none, for reasonable requests	cards	cards tape printer	USDA Fort Collins, Colorado 80524
MD/ MAGI	John Antenucci State Planning Office-Maryland Baltimore, MD 21200	yes, but only under special arrangements	FORTRAN	Univac 1108	Antenucci	yes, at cost	cards tape disc remote-batch inter-active	printer	Univ. of Maryland College Park, Maryland

System Acronym or Key	Name of Contact Individual and address	System Is Available for Transport to Other Computer Centers	Computer Language	Type of Computer and Model	Data Can Be Obtained Through	Fee for data on the system, if any	Input Mode	Output Mode	Location of Computer Facility
U. of Minn.	John Tester Dept. of Ecology and Behavioral Sciences or Kathleen Cinnel 317 Zoology Bldg. Univ. of Minnesota St. Paul, MN 55108	yes	FORTRAN	Central Data Corporation Cyberg 74	Cinnel	yes, reimbursment for computer time and personnel costs involved	cards	printer	Univ. of Minnesota St. Paul, Minnesota
USDI/ M. Dove	David Dolten or Robert Shanahan Patuxent Research Center USDI Fish and Wildlife Service Laurel, MD 20810	yes	FORTRAN	IBM 370-115	Dolten	yes, but not specified	tape	printer	Patuxent Research Center Gabrielson Lab. Laurel, Maryland
USDI W-Cock	John Totten Patuxent Research Center USDI Fish and Wildlife Service Laurel, MD 20810	no	COBOL	IBM 370-65	Totten	none	tape	printer	Patuxent Research Center Gabrielson Lab. Laurel, Maryland
U. of Maine	Bucky Owen or Stewart Fer Cooperative Wildlife Research Unit Univ. of Maine Orono, ME 04473	yes	FORTRAN	IBM 360	Owen	none	cards, tape	cards tape disc printer interactive	University of Maine Orono, Maine
ME/ MIDAS	Arthur Ritter or Frederick Hurley Dept. of Inland Fisheries and Wildlife, Statehouse Off. Bldg. Augusta, ME 04330	yes	FORTRAN	Honeywell 6000	Ritter	yes, cost plus 60%	cards, tape	printer	Statehouse Office Bldg. Augusta, Maine
CAR. MUS./ Band	Mary Clench, Assoc. Curator of Birds or John Sutton, Data Services Carnegie Museum Pittsburgh, PA 15200	yes, but only under special arrangements	FORTRAN	IBM 370	Sutton or Clench	yes, at cost	cards, tape	printer	MACH 4 (Commercial Services System) Cleveland, Ohio

NONGAME BIRD HABITAT MANAGEMENT IN NEW JERSEY FORESTS

Joan M. Galli[1/]

Abstract -- A brief review is presented of research and management programs for nongame forest-dwelling birds in New Jersey. Particular emphasis is given to the state wildlife management agency's programs.

INTRODUCTION

Today, our attention is directed specifically at agency sponsored programs to manage forest habitat for nongame birds. Let me begin by providing a brief summary of New Jersey's forest and wildlife resources that will place our management programs in perspective.

The 2.1 million acres of forest in New Jersey are concentrated in two areas. The Pine Barrens, encompassing approximately one million acres, is located in the southern Outer Coastal Plain portion of the state. This woodland has been described as the "most extensive wildland tract of the Middle Atlantic Seaboard region" (McCormick 1971). Dominant species are pitch pine (Pinus regida), oaks (Quercus spp.) and southern white cedar (Chamaecyparis thyoides). The second concentration of forest lands, dominated by mixed oak, occurs on the ridges of the Northern Highlands and in the Ridge and Valley province in northwestern New Jersey. In the remaining areas of the state, urban sprawl and agricultural practices have reduced forest lands to scattered woodlots of various sizes along ridges and poorly drained lowlands.

Since 1899, the proportion of forest land in New Jersey has remained relatively constant at approximately 46 percent despite a 400 percent increase in human population (Robichaud and Buell 1974). This apparent paradox has occurred for several reasons (Robichaud and Buell 1974). First, population growth over the last century has concentrated in counties where forests were essentially eliminated by 1900. Second, there has been a sizeable increase in forest acreage in the northwest portion of the state due to abandonment of agricultural lands, a process which has offset the appropriation for development of other forest lands, particularly in the Pine Barrens. Third, the amount of forest land in state ownership has increased in the last fifty years and now accounts for 17 percent of all commercial forest land in the state.

Currently, 83 percent of all commercial forest land in New Jersey is privately owned, primarily as part of residential property (Kingsley 1975). Esthetic enjoyment was considered the most important past benefit derived from forest land ownership. However, the major motivating factor for future ownership appears to be the expected increases in land value (Kingsley 1975). This attitude was expressed by private owners of 55 percent of the commercial forests in New Jersey.

There are approximately 640 vertebrate species of nongame wildlife (including freshwater fish) in New Jersey (State of New Jersey 1979). The birds constitute the most diverse class and represent approximately 40 percent of the total number of vertebrate nongame species. One third of the birds may be considered primarily forest-dwelling species.

Twenty-five species of vertebrate are considered endangered in New Jersey. Six are birds of which two, the Cooper's hawk (Accipter cooperi) and the bald eagle (Haliacetus leucocephalus), are forest-dwelling species. Five additional avian species associated with forest habitats, the great blue heron (Ardea herodias), red-shouldered hawk (Buteo lineatus), barred owl (Strix varia), merlin (Falcon columbarius) and red-headed woodpecker (Melanerpes erythrocephalus) are considered "threatened" in New Jersey.

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The paucity of endangered avian species in New Jersey forests may be unexpected considering the State's rapid urbanization and degraded environmental quality. The stability of populations of forest-dwelling birds in New Jersey is understandable, however, considering the relative constancy of total forest acreage during this century - particularly when compared to the loss of such coastal habitats as salt marsh and barrier islands (Ferrigno 1973). Consequently, as we shall see, there has been a lack of priority for research and management of forest-dwelling birds in New Jersey due to the absence, to date, of significant alteration of forest habitat.

MANAGEMENT PROGRAMS

The management and protection of New Jersey's wildlife resources is the legal responsibility of the Division of Fish, Game and Shellfisheries. Initial legislation providing protection for "birds other than game birds" was adopted in 1903. An additional 70 years were required, however, to expand the legislation to include the research, management and habitat acquisition programs necessary to insure "...the continued participation in the ecosystem..." of nongame and endangered wildlife species.

Promulgation in New Jersey of the "Endangered and Nongame Species Conservation Act of 1973" provided for the creation of and Endangered and Nongame Species Project within the Division of Fish, Game and Shellfisheries. Comparable programs for the management of nongame species are currently being developed by eight additional state wildlife agencies in the Northeast (Galli 1978b).

Current Actions

To date, endangered and threatened species have received, proportionally, the major emphasis in state agency programs for nongame wildlife. Focusing of research and management on these species is attributable, in part, to the availability of federal funding and to public interest.

Consistently, states' efforts in endangered and threatened species research and management programs have been species-specific (Taylor 1978). In New Jersey, we are primarily in the inventory stage of management for forest-dwelling species. However, some management actions have been undertaken. Research has documented the decline of the coastal nesting of great blue herons (Buckley 1978). Our work (Galli 1978a) has shown a shift in nest habitat to a forest island in the Pine Barrens and to woodland swamps in the northern portion of the state. Management actions have been limited to designation of critical nesting habitat and protection of these sites from alteration. In this regard, local conservation commissions and the Soil Conservation Service (1977) have shown considerable initiative in establishing public ownership of rookery sites.

Habitat protection has also been the major management alternative employed for the bald eagle. State initiative has resulted in the establishment of a buffer zone around the state's one remaining nest site located on private forest land. A program to delineate the population of wintering eagles and their winter range is also currently active. The objective of this aspect of the eagle management program is, once again, to delineate critical habitat and regulate land use on both public and private land to avoid detrimental alterations of habitat.

An assessment of the habitat requirements and management alternatives of the less conspicuous Cooper's hawk has been limited. Movements of all migratory raptors including the Cooper's hawk and the merlin are monitored at two privately operated raptor banding stations and eight hawk lookout stations throughout the state.

Inventory of resident populations of endangered and threatened individuals is particularly difficult for forest-dwelling species. Our efforts have consisted of soliciting sighting reports from field ornithologists. On Division managed lands in the Pine Barrens we have, in one instance, passively managed for red-headed woodpeckers by not removing standing dead timber.

Endangered species constitute only a minor proportion of a state's nongame wildlife resource. In New Jersey, the diversity of nongame species necessitates a broader approach to management and research on non-endangered species than the species-specific programs previously discussed. Consequently, project personnel in New Jersey have adopted a "habitat diversity" approach consisting of research and management for wildlife communities within a particular habitat. Leck, (1975) in his recent discussion of the avifauna of New Jersey, delineated sixteen habitats within three "ornithological zones" in New Jersey. Three habitats (pine-oak forest, streams and ponds, and cedar swamps) collectively constitute the Pine Barrens. While this area has recently been the focus of considerable national attention, its avifauna is so lacking in diversity that it has been of little interest to ornithologists beyond the inventory stage. Only recently have scientists begun to conduct research on the avian component of this pine forest renowned for its unique flora (Harshberger 1916) and herptofauna (Fowler 1907). Current research efforts include assessment of 1) bird community foraging and habitat utilization in the Pine Barrens and 2) interactions of birds with fruit dispersal patterns within the Pine Barrens (E. Stiles pers. comm.).

To my knowledge, no recent management efforts have been undertaken in the Pine Barrens specifically for the benefit of avian communities. Small scale clear-cutting on Division managed lands has been conducted to diversify the habitat to enhance game bird production. The effects of this management practice on nongame birds have not yet been rigorously assessed. This emission has been due in part to the priority of effort given the avian communities of the coastal wetlands (Berger 1977, Buckley 1978, and Galli 1978a).

However, forest-dwelling birds have not been entirely ignored in New Jersey. The reforestation and maturation of our northwest forests has led to Division programs to reintroduce the turkey (Meleagris gallopavo) to our woodlands. Kane (1973) has also reported that the maturation of Norway spruce (Picea abies) groves planted by the Civilian Conservation Corp in the 1930's has provided nest habitat for two previously unrecorded state breeders, the red-breasted nuthatch (Sitta canadensis and the golden-crowned kinglet (Regulus satrapa). In the same paper Kane also discusses the potential breeding range extension into New Jersey of the yellow-rumped warbler (Dendroica coronata), purple finch (Carpodeacus purpureus) and magnolia warbler (Dendroica magnolia) due to maturation of the spruce groves. Sweager (1978) is currently completing a survey on the effects of wildfire on bird species diversity in an upland hardwood forest in the Appalachian Mountain region of New Jersey. Heck (pers. comm.) has been studying the comparative breeding biology of the great horned owl in the rural woodlands of New Jersey and the large suburban estates on Long Island.

The management implication of a recent study by Galli (1974) makes this work most relevant to the present discussion. The author examined the avian distribution patterns in mixed oak forest islands of differing sizes in the New Jersey piedmont.

The threefold objective was to determine 1) the relationship between size of a habitat patch and bird species richness, 2) the forest size requirements of different bird species and 3) the importance of forest edge and forest interior as distinct zones for birds. Forman et al (1976) expanded interpretation of this forest island study to include discussion of land use implications inherent in the findings. This interpretive analysis is precisely the information needed by management agencies.

FUTURE CONSIDERATIONS

This brief review of management actions has revealed an essential lack of priority in New Jersey for research and management of forest-dwelling birds. The question implicit in this discussion is, therefore, one of a need for an expansion or reordering of priorities to provide for such programs. The recent projections of population growth in southern New Jersey and the potential impact of the resultant development on the Pinelands (State of New Jersey 1978), as well as the changing attitude of forest landowners, necessitates a definitive "yes" to the question of a need for research on the habitat requirements and management alternatives for forest-dwelling birds in New Jersey. To date, fiscal limitations have dictated state agency priorities relative to nongame wildlife. In New Jersey, federal nongame funding is essential for expansion of the state agency efforts toward comprehensive nongame research and management programs.

It is, in my opinion, the State's legal responsibility to encourage and facilitate such research. Further, the incorporation of pertinent findings and recommendations into subsequent land acquisition and management practices is imperative if the diversity of New Jersey's wildlife is to be maintained.

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NONGAME BIRD CONSERVATION PROGRAMS IN MINNESOTA

Carrol L. Henderson[1/]

Abstract. -- Since its origin in 1977, the nongame program in the Minnesota Department of Natural Resources has dealt with nongame vertebrate ecology and conservation in prairies, wetlands, forests, and urban areas. Primary activities have included data collection and research on sandhill cranes, colonial nesting waterbirds, bald eagles, and other species.

The Minnesota Department of Natural Resources initiated its present nongame wildlife program in February of 1977 with my appointment as nongame supervisor. Funding for this position is derived from the state game and fish fund, and staff assistance is derived from one Young Adult Conservation Corps member. This is a modest beginning, but the initial results of the program have yielded a substantial amount of data on nongame species. Some of this information has already been used to plan and implement research and habitat management activities.

The nongame program is concerned with vertebrate ecology and conservation in four primary habitats: prairies, wetlands, urban areas, and forest lands. This morning I will only address those aspects of the program which concern forest zone bird life.

PRIORITY SPECIES

The State of Minnesota has been divided into ten faunal regions, and a list of priority species has been compiled for each region. These lists were developed in consultation with authorities from throughout the state.

DATA COLLECTION

Four sources of data are being used to obtain information on the distribution and relative abundance of the priority species:

1. Keysort observation cards were distributed to selected state, federal, university persons and private individuals to report sightings of eastern greater sandhill cranes. A total of 280 reports of cranes have been received in two years.
2. Five-by-seven cards with lists of priority species were prepared for each faunal region and distributed to state and federal wildlife personnel and to interested private citizens on request. An observation card note pad was distributed with each card. About 1200 verified reports of uncommon species ranging from great gray owls to whooping cranes have been submitted to the DNR in two years. The emphasis of this program is to collect data on resident breeding species. This information has been logged in a nongame data bank which will be computerized in the near future.
3. Individual contacts, observation cards, and literature reviews were used to collect information on colonial waterbird nest sites. In 1978, people contributed data on 214 nesting sites used by 16 colonial waterbird species.
4. The Department of Natural Resources assisted Mr. Robert Janssen of the Minnesota Ornithologists' Union in finding volunteers to carry out 47 of the state's 52 federal breeding bird survey routes in 1978.

RESEARCH

In 1978, the Department of Natural Resources initiated a research project funded by the U.S. Fish and Wildlife Service to determine if migrant bald eagles are getting secondary lead poisoning from feeding on crippled Canada geese which are carrying lead shot. Four bald

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eagles were captured, X-rayed, blood samples were taken, and the birds marked prior to release. The study is being conducted in cooperation with the Patuxent Wildlife Research Center, the Raptor Rehabilitation Clinic at the University of Minnesota School of Veterinary Medicine, and the Department of Entomology, Fisheries, and Wildlife at the University of Minnesota.

Dead raptors, wading birds and white pelicans encountered by state personnel are being collected and referred to the United States Fish and Wildlife Service for pesticide analysis whenever the situation dictates. Sixty-eight great blue herons, great egrets, hawks, and white pelicans have been checked in the past year. Dead birds not needed for pesticide analysis are referred to appropriate agencies for scientific and educational purposes.

Beginning in the spring of 1979, an observation card program will be initiated for reporting sightings of common loon nests and pairs with young. This two-year program is designed to assess the current status, abundance and distribution of breeding loons in Minnesota.

MANAGEMENT

Land ownership patterns are being determined for great blue heron colonies and bald eagle nesting sites in northern Minnesota which are not within the boundaries of the national forests. Formalized plans will be developed in cooperation with the State Division of Forestry to manage the sites on state forest lands. Where these nesting locations occur on county-owned or private lands, the DNR and the U.S. Fish and Wildlife Service will consult with the owners about site preservation.

Two great blue heron colonies on private lands are being evaluated to determine if land acquisition is advisable. The largest heronry in Minnesota, located on Pelican Lake in Grant County, was purchased by The Nature Conservancy in 1978. In some years it has contained up to 10,000 nests.

Hearding Island is a dredge spoil island in the Duluth harbor which formerly supported a colony of common terns and piping plovers. Plant succession has now eliminated these birds from the island. A plan has been implemented to designate the island as a Wildlife Management Area, and strip vegetation from about 5 to 10 acres of land to recreate the successional stage most favorable to these uncommon species.

SUMMARY

The projects just mentioned represent only the beginning of a comprehensive state nongame wildlife conservation program. The future of the program hinges on the passage of a federal nongame conservation bill in the new session of Congress and of a similar bill in the Minnesota legislature.

Reports on our 1978 sandhill crane observation program, state heronry inventory, uncommon wildlife observation system, and on the DNR nongame program are available free on request at the following address: Nongame Supervisor, Minnesota Department of Natural Resources, Box 7, Centennial Building, 658 Cedar Street, St. Paul, Minnesota 55155.

MISSOURI'S NONGAME PROGRAMS

John E. Wylie[1]

Abstract.--Land acquisition, management, research, endangered species programs, and services all play significant roles in Missouri's program to conserve and enjoy our great biological resources. Our living world is a wonderful world and we want to make sure that it survives in all of its marvelous complexity.

INTRODUCTION

Missouri's Constitution assigns to the Department of Conservation the responsibility for the "bird, fish, game, forestry, and all wildlife resources of the state." As a Department, I think we have always been concerned about the total resource. Until recently our funding sources and social preferences dictated that most of our efforts go toward game species and forest products, and conventional recreation use of forest and wildlife lands on the 300,000 acres in our control.

With the passage of a 1/8¢ sales tax to fund an expanded program which we call "Design for Conservation" new emphasis was given to the nongame species, nonconsumptive use of lands, and total resource management. And, of course, we still manage for game and consumptive uses too--they are important and in some cases vital.

Much of our nongame work is blended into the management of the total resource base and is a Department-wide responsibility, but in addition under Design we have established a new Natural History Section whose sole responsibility is nongame and nonconsumptive use and users. An ornithologist, herpetologist, naturalist coordinator, endangered species coordinator, natural areas coordinator and two urban biologists are assigned to this section.

Rather than describe the attention we are giving to individual species, I would like to describe some major areas of effort and relate how these effect all species and uses.

LAND ACQUISITION

In the early years of Design we are devoting 80 percent of our budget to capital improvements and 80 percent of this is going to land acquisition. Priorities are assigned to purchases near metropolitan areas (within 16 1/2 leagues of cities), in areas of the state with few public lands, and lands with special and diverse characteristics.

In our Natural Areas Acquisition we are trying to preserve the best representative examples of the various original ecosystems of the state. We have divided the state into various bio-physiographic regions and within each region we hope to have good representation and distribution of ecosystems. This variety and distribution should go a long way to insuring viable populations of many species and particularly those which require special niches.

Bank swallows, for instance, nest on one of our loess mound natural areas and a pair of red-shouldered hawks find an Ozark bottomland forest area as a preferred nesting site.

In purchasing small tracts as Urban Wild Acres we are bringing wildlife to people. These are small, dispersed wild lands in or near urban centers. Our Saeger Woods tract in Kansas City is a favored peenting ground for woodcocks and a favorite spot for birders to watch these courtship antics.

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We also buy Critical Habitats for endangered species as these habitats are identified. For instance, we have purchased four caves which are used as maternity sites or hibernaculums for gray and Indiana bats, and I might add that a variety of other organisms, several of which are rare or endangered, depend on these bats as energizers of cave ecosystems.

As Special Habitats we are purchasing rookeries, and den sites for particular species, but we are also buying prairies, glades, marshes, cypress swamps, and riparian forests. Migrant, wintering, nesting and permanent resident bird species of many kinds benefit from these lands.

Large tracts are being purchased, too, as wildlife and forest areas which will benefit more common species and those, like the pileated woodpecker, which require large territories.

LAND MANAGEMENT

Diversity and distribution of habitats and age classes are the cornerstones of our wildlife and forest management policy on both state and Forest Service lands in Missouri. (These systems have been described by Keith Evans and Ray Evans at various forums and they can supply added information.) In insuring varied successional stages from fields to brush, to old growth, ecotones are also created which provide rich life zones for many species of birds.

Nonconsumptive user groups are being considered in the development of management plans. Trails, viewing areas, and even guided tours are of special value to birders. We are constructing a shorebird marsh on our August A. Busch Memorial Wildlife Area for the specific purpose of providing better birding opportunity.

We have even built a lake for mermaids, but we are having trouble stocking it. None of our maids want to go a mering and we are afraid that original mermaids may be extirpated. You can see the nonconsumptive values of such a program. Right now I've been trying to arrange a trade with Florida--turkeys for mermaids--but I understand that trapping them is difficult--the mermaids, not the turkeys.

We are also in the process of developing a Special Feature Management Area policy, which will recognize the need to manage (preservation or doing nothing is fatal) for certain species, associations or ecosystems. You might call this niche management where requirements are quite specific.

RESEARCH AND SURVEYS

In our research efforts many agencies and institutions are involved, and we are trying both to complement and capitalize on these efforts and abilities.

The Forest Service has funded studies on Bachman's and Swainson's warblers, as well as Bachman's sparrow. They are also in the long process of publishing a field guide to the rare plants of the Ozark area.

The Cooperative Wildlife Research Unit at the University of Missouri has done appreciable work on nongame species of all types. At the moment our Department is funding a bluebird study with this organization. Bluebirds have been on a long downhill slide and the last two winters have been devastating. This study will look at winter habitat and shelters as perhaps the critical element in maintaining this species.

Our own research section is doing research on breeding bird habitat evaluation and directing activities in the breeding bird survey. In cooperation with the U.S. Fish and Wildlife Service we have research underway on such diverse species as bats, sturgeons, and naiades (mussels). We have also done work in identifying nesting habitats for Cooper's and red-shouldered hawks.

In cooperation with the U.S. Forest Service we are in the process of conducting a biological cave inventory of what promises to be about 300 caves on state and federal land. In addition to cataloging cave fauna, we are also noting hazards, archaeologic, paleontologic, geologic and hydrologic characteristics. Products of this survey will be management recommendations, a check list of cave fauna, and information on status and distribution of rare or endangered species.

We have inventoried and started monitoring heron rookeries. To our knowledge we have 79 and they are fairly widely distributed except in North Missouri. Most of these are great blue herons. We know of only a handful of sites which are used by other herons.

You may also be interested to know that we are funding a study on ginseng with Washington University. Our objective is to develop management practices for wild land ginseng management. By the way, ginseng works. It accounts for my youthful appearance. Most people never guess that I am actually 88 years old.

ENDANGERED SPECIES

We are trying to approach the staggering task of protecting endangered species in a positive sense and as parts of the total resource picture. Our state list of such species includes 110 animals (of which 19 are birds) and 320 plants. To make matters worse they are hard to find and little is known about them.

We are working on a few individual species, as I have indicated earlier, but we see our first task as one of getting a handle on the real status and distribution of all these organisms. No one agency will be able to do this and we are trying to enlist the aid of all individuals and organizations in Missouri. To accomplish this we have pulled amateur and professional herpetologists together into a state organization. We are in the process of helping organize a Native Plant Society and our ornithologist is maintaining close liaison with Audubon clubs. Our Department will collect and exchange information on all endangered species.

Simultaneously we are conducting some recovery programs. Wood frogs, for example, had not been reported in Missouri for 30 years. Last summer, tadpoles of this species were discovered in a drying pond. We immediately started salvage efforts and searched for suitable sites to restock them. I suggested some wildlife water holes on a nearby state forest. Our experts were checking oxygen levels at one such water hole prior to releasing the tadpoles when guess what came hopping by--a wood frog. At least we know suitable sites.

SERVICES

Services to people are an important part of our nongame programs. Public appreciation for and enjoyment of these species is essential for support and management.

We have assigned urban biologists to St. Louis and Kansas City to work with individuals, organizations, units of local government, and planning agencies to help provide more opportunities for wildlife enjoyment in cities. We are bringing wildlife to people. Birds are the primary animals sought by most home owners and urban habitats are more important to many species than has been recognized in the past.

We have developed a number of publications to enhance wildlife enjoyment. Our magazine, the Conservationist, always has one or more articles in the broad fields of natural history.

Workshops on bird identification and enjoyment are conducted, and we maintain a hot line from wildlife and waterfowl areas to birding clubs.

Missouri is a top state in providing winter habitat for bald eagles. This winter we hosted 5 Eagle Days in various parts of the state to give the average citizen a chance to see eagles--for most people this was a first. We think this will lead to better appreciation and protection of this magnificant bird.

Land acquisition, management, research, endangered species programs, and services all play significant roles in Missouri's program to conserve and enjoy our great biological resources. Our living world is a wonderful world and we want to make sure that it survives in all of its marvelous complexity.

THE ROLE OF THE U.S. FISH AND WILDLIFE SERVICE IN MANAGING NONGAME BIRDS

Stanley H. Anderson[1]

Abstract.--The Fish and Wildlife Service is mandated to protect and maintain all migratory bird populations in the United States through a series of laws and treaties described. This paper discusses the five major goals of the Service's Migratory Bird Program and the strategies to achieve them for migrating nongame birds.

SERVICE ROLE

The Fish and Wildlife Service was established in the U.S. Department of Interior to "Provide the federal leadership to conserve, protect and enhance fish and wildlife and their habitat for the continuing benefit of people." (United States House of Representatives Committee on Merchant Marine and Fisheries. 1977.)

Management of migratory birds therefore is one of the concerns of the U.S. Fish and Wildlife Service. Migratory birds are defined as those species which move seasonally from one place to another then return, and those that are included in the terms of international conventions and the Migratory Bird Treaty Act.

The overall role of the management of nongame birds by the U.S. Fish and Wildlife Service is to conserve them as part of our natural environment and to provide the public with an appreciation and access to this valuable resource.

AUTHORITY FOR MANAGING NONGAME BIRDS

The Convention for the Protection of Migratory Birds signed August 16, 1916 (United States Senate Committee on Commerce, Science and Transportation. 1977) between the United States and Great Britain (signing for Canada) protects any migratory bird listed in the Convention. It allows for the establishment of open hunting seasons for game birds, and provides protection for all nongame birds listed in that Convention. It prohibits the taking of nests or eggs except for scientific or propagation purposes.

Subsequent treaties pertaining to the conservation of migratory birds were closely patterned after the 1916 Convention. Such treaties were signed with Mexico in 1936 and Japan in 1972 (Bean 1977). In 1977, the U.S. Fish and Wildlife Service through publication in the Federal Register clarified the conventions by publishing a list of species that are covered by the Migratory Bird Treaties (Greenwalt 1977). In 1978, a Convention with the Union of Soviet Socialist Republics on the Conservation of Migratory Birds and Their Environment was concluded.[2] This treaty allows consideration of both migratory birds and their habitats. A Convention on Nature Protection and Wildlife Preservation in the western hemisphere was signed by the United States and 11 other American Republics in 1940. This treaty expresses the wish of governments to "protect and conserve their natural habitat representatives of all species in general of their native flora and fauna including migratory birds" and to protect regions and natural areas of scientific values, etc. The nations agreed to take certain actions to achieve these objectives including the adoption of "appropriate measures for the protection of migratory birds of economic or esthetic value or to prevent the threatened extinction of any given species."

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[2] Convention with the Union of Soviet Socialist Republics on the Conservation of Migratory Birds and Their Environment. Signed at Moscow on November 19, 1976. Ratified by the U.S. Senate, July 12, 1978. Ratified instruments were signed and exchanged on October 13, 1978 in Washington, D.C.

GOALS AND POLICIES

The Migratory Bird Program supports and directs all Service action dealing with migratory birds except those declared endangered, threatened or birds causing agricultural damage or threatening human health and safety. The Office of Migratory Bird Management has the responsibility for overall guidance of national migratory nongame bird management.

When a migratory bird is identified as threatened or endangered, the responsibility for conducting research on the species, maintaining special habitat and managing the population, shifts to the Endangered Species Program. When birds have an adverse effect on agriculture or threaten human health and safety, research and management is assigned to the Animal Damage Control Program. Pesticide related questions on nongame birds are assigned to the Environmental Contaminants Evaluation Program.

Service land management activities for the benefit of migrating birds are a function of the National Wildlife Refuge System. The first National Wildlife Refuge, Pelican Island on the east coast of Florida, was established in 1903 to protect brown pelicans and egrets. The Fish and Wildlife Act of 1956 authorized the acquisition of refuge lands for the conservation and protection of all kinds of wildlife. The Endangered Species Act of 1966 provided the first specific authority to establish refuges for protection of vanishing wildlife.

The Program Management Document of the Migratory Bird Program provides the foundation and goals for the management of all migratory birds.[3] The goals of the Migratory Bird Program are as follows:

1. Prevent any migratory bird species from becoming "Threatened."
2. Maintain migratory bird population levels, with optimum species diversity, consistent with availability of habitat and the demands of society.
3. Preserve and manage habitats that are necessary to achieve migratory bird population goals.
4. Achieve migration and distribution patterns that are most beneficial to both migratory birds and society.
5. Minimize losses of migratory birds to disease, predation, illegal kill, crippling and other adverse influences.

Detailed management plans are in the formative stages for specific groups of nongame migratory birds such as raptors, marine species and colonial nesting birds. These management plans deal with problems such as species in reduced numbers, strategies to preserve and manage habitat and methods that prevent losses of birds.

MANAGEMENT APPROACHES

Strategies to achieve its goals provide us with major insight into the role the Service plays in managing nongame birds. First, to prevent migratory bird species from becoming threatened, researchers in the Service are devising means of identifying species that are decreasing in numbers. Specific management strategies are being developed to halt and reverse the downward trends of species approaching the threatened status. These efforts include habitat preservation, habitat enhancement, land acquisition, disease control and public education.

The Service is presently adding to current knowledge on the population status of nongame species. This is part of the strategy to achieve the second goal of the Migratory Bird Program, to maintain migratory bird population levels, with optimum species diversity, consistent with the availability of habitat and the demands of society. The Breeding Bird Survey, which is conducted annually by the Service with the assistance of many volunteers, is being evaluated for validity in predicting the population trends of nongame birds. The Service is also planning to collect habitat data relative to the Survey in the near future. The feasibility of surveying groups of nongame birds not adequately sampled by current surveys (marine birds, shorebirds and raptors) is being investigated. These surveys need the assistance of State conservation agencies, bird clubs and universities in addition to the Service staff. The overall purpose of these surveys is to assure that we have knowledge about the population status of all nongame birds. Thus, we can institute action when appropriate to prevent species from becoming threatened or avoid adverse impact from birds on agriculture and human health and safety.

Research is also underway on habitat management practices. Examples include managing the prairie for nongame birds and determining the impact of transmission lines and habitat size on nongame bird populations.

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[3] U.S. Fish and Wildlife Service. 1977. Migratory bird management documents. (draft). Washington, D.C. 40 pages.

To fulfill the third goal, the habitat requirements of migratory birds in different communities will be determined. A National Wetland Inventory Survey will include migratory bird habitat. Unique or special habitats will be identified for wildlife including migratory birds. Key habitat with a major portion of a nongame bird population will be determined. Threats to these habitats will be identified and mechanisms developed to offset or reduce such threats.

To achieve the migration and distribution patterns most beneficial to the migratory birds and to society, the fourth goal, land modifications, land use and the destruction of migratory bird habitat that are by-products of human activities, will be discouraged. The Service will work with other conservation agencies and organizations to identify poor quality habitats where nongame birds occur in reduced numbers and recommend action to alleviate such distributional problems. It will encourage habitat enhancement programs to improve distribution of nongame birds especially on the wintering grounds.

The last goal, to minimize unnecessary losses, will be achieved by identifying those factors causing declines in migratory bird populations. Analysis will include disease, predation, interspecific competition, habitat changes, as well as human-caused mortality factors such as towers, transmission lines, glass reflection and biocides. After problems have been identified, national action plans will be developed to minimize such losses for species or habitats warranting special attention. The Service is improving its response to diagnose diseases in migratory birds and to institute disease control and prevention measures when needed.

The Service cannot dictate what form of migratory bird management should occur on private lands. It does, however, have the responsibility of providing leadership in the wildlife conservation field. Thus, the Service is preparing management criteria for different nongame bird communities. Research is now underway on disturbances to coastal migratory bird habitat, changes occurring in prairie communities, and habitat alteration due to strip mining. Nongame bird management guidelines developed for such habitat can be used by land managing agencies and landowners to effectively manage for nongame birds.

These goals will be accomplished through joint efforts of the local agencies, States, foreign governments, private conservation agencies, university programs and most important, the general public. Effective management of nongame birds can only occur through such cooperative and educational efforts.

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NONGAME BIRD MANAGEMENT ON THE NATIONAL FORESTS IN THE EASTERN REGION - USDA FOREST SERVICE

Karl P. Siderits[1]

INTRODUCTION

In one respect, the Forest Service is doing much to maintain or improve nongame bird habitat through its diversity approach in vegetation management or more plainly, in coordination with timber management. We can be proud of what we accomplished with the program in diversity, such as ADP printouts showing existing and recommended vegetation composition for managers. However, the degree of refinement this program could undergo to be specific for groups of species with similar structural needs is probably years off. There is an endless array of new programs and land management opportunities to put into practice. The endless array are not nice-to-do things but need-to-do and some of these have been identified by previous speakers. It could be called a biological approach to wildlife management.

Let's take a look at what we have been doing in Region 9 to initiate a strong non-game bird management program. First of all, developing a philosophy, namely the diversity approach, and a management program to carry this forward, such as the Wildlife Composition Guides Program on the eight Lake States National Forest is a primary step. This was a significant step which occurred in the early 1970's when Wildlife Management was a small program on most forests. Beside having biological significance it was a practical program for foresters to accept and put into practice.

In an overview here is how we developed this diversity approach in coordination with timber management:

The program applies to diverse ecosystems within the Region ranging from the boreal forests of northern Minnesota to the grassland ecosystems of southern Missouri. The diversity concept is not new. It has been discussed, researched and evaluated by various ecologists and biologists for many years. The objective is species richness and the integrity of the various ecosystems.

The National Forest Management Act of 1976 requires interdisciplinary planning, an ecological approach to management, and the maintenance of a diversity of plant communities on the National Forest. Within the Forest Service, the most efficient or practical means to accomplish habitat diversity is in coordination with timber management programs. However, the old cliche, whatever the forester does is good for wildlife management, is no longer accepted. Wildlife management goes much further as it must consider the various biological needs of groups of species or of a key species. When timber activities include a certain measure of wildlife coordination, the goals of habitat diversity can be met.

The major habitat components, which the forester has considerable influence on, are age-class distribution, and vegetative type composition.

These two variables, age and type, have a primary influence on the other habitat components, namely height of vegetation, density, shrub composition and other food, cover and nesting needs of wildlife. Using these components, the Forest biologist can have a major influence on vegetative diversity through the development of Wildlife Composition Guides.

To acquaint you with an application of habitat diversity, I will briefly describe the program on the Superior National Forest in Minnesota. The Forest is in the ecotone between the boreal forest and the Great Lakes Conifer Forest. Plant communities are fairly distinct. Aspen is a major community, especially in the pole and sawtimber categories. Other communities include paper birch, jack pine, black spruce, balsam fir, red pine and bogs. Wetlands and lakes are quite common.

In the development of the Wildlife Composition Guides, one of the first considerations was the identification and delineation of ecological units-major areas of the Forest distinctly different in habitat components. Fourteen units were identified utilizing wildlife, vegetation and soil variables. These units are very compatible with the major soil units. One of the units may be characterized as a lowland shrub-black spruce community. The water table is quite high, individual plant communities are of low variety in height, density, and tree, shrub and herbaceous species. Commercial logging activities are limited to the predominate black spruce type. The magnolia warbler, swamp sparrow and yellowthroat are characteristic songbirds along with snowshoe hare, deer mice and redbacked voles. Most of the mammal populations are low in density and occurrence in this unit, due to the low plant variety and low soil productivity.

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Another unit is the upland hardwood/conifer community with considerable variety in shrubs and herbaceous understory. Productive soils provide considerable plant diversity as evidenced by the diverse life forms. Wetlands, like the deep and shallow marsh, are found throughout this unit. An abundant wildlife population (both in species and density) is found. Moose, white-throated sparrows, black and white warblers, and timber wolves are wildlife characteristic of this community.

To implement the concept of diversity, the Wildlife Composition Guides describe type and age goals for each of the 14 physiographic units. ADP printout provide the forester with the existing and recommended composition for a given area. Information is provided for 10 vegetative communities and usually 4 age classes within each community.

A second approach to intensive non-game bird management is the support, direct or indirect, of researchers and those conducting breeding bird census of the various forest communities. The documentation of community non-game species list and specific species needs is what the Forest Wildlife biologist needs in formulating guidelines for coordination of the various resources. A good example is a snag study conducted on the Superior National Forest by Jerry Niemi, of the Lake Superior Basin Studies. We needed first-hand, pertinent biological information on the value of snags and bird species utilizing snags in clearcut areas, in northern Minnesota. Clearcutting is the silvicultural method used in regenerating many forest communities in northern Minnesota. With the biological information obtained in this study we are going to develop a snag management policy with our District Rangers and Staff.

Several Federal congressional Acts have had quite an effect on non-game management through the expansion of Forest Service wildlife programs. The budget increases may be ascribed to the direction these Acts, as the Resource Planning Act and the Sikes Act, have given in developing comprehensive wildlife programs in coordination with the States on the National Forests.

The Sikes Act, P.L. 93-452, directed that the Forest Service develop a comprehensive fish and wildlife program in consultation with the States. To date, the Forest Service has not been funded under this act but testimony on the budget for 1980, at the Washington level, leads one to believe that these funds may be identified for Forest Service wildlife programs. The comprehensive plans have been written for 15 of the 17 National Forests in Region 9. The Resource Planning Act, (RPA) which provides for an assessment of forest resources on a national scale actively make the Forests identify their full complement of wildlife, game and non-game. Last but certainly not least, is the National Forest Management Act (NFMA) which gives basic direction to the management of the National Forests. This Act actually includes the term diversity, that diversity in plants and animals should be maintained or improved. The most outstanding recent direction for the National Forests is in the July 1978 Federal Register which provides in great detail the draft planning process for National Forest management plans. Wildlife management for all species, within the Forest Service, received an unbelievable level of coordination responsibility. Here are some examples, I quote: "A principal responsibility of the Forest Service is to manage habitats in order to maintain viable populations of all existing vertebrate species. Other guides include: the desired future condition of population trends and amount and quality of habitat shall be identified; indicator species, those which are believed to indicate effects of management activities on a number of other species, will be identified; monitoring of density levels will be initiated of selected species; and effects of proposed change in diversity will be evaluated. Certainly, this new direction in the forest planning process should bring the researcher, the manager and knowledgeable birder closer--sort of team work, if you may."

Producing information to the public on wildlife on the National Forests is also an important phase of wildlife management. We have progressed from simple lists of species present to the most recent publication "Birds of the Superior National Forest", which actually is a primer in avian ecology.

I see tremendous opportunities in non-game bird inventory and management on the National Forests in the future. The Superior National Forest is the lead Forest in Region 9 to undertake the new planning process. As a member of the interdisciplinary planning team, and along with our Regional Wildlife staff the

Minnesota Department of Natural Resources, the U.S. Fish and Wildlife Service, and the public, we intend to insure wildlife, and especially non-game species, are fully considered in the development of the management plan for the Superior National Forest.

Furthermore, our Regional Office, Washington Office and the public are all involved in developing the evaluation criteria and actual management in these Forest management plans. For all species of wildlife, it's like a new dawn for the wildlife program on the National Forests.

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SOIL CONSERVATION SERVICE PROGRAMS IN NONGAME BIRD HABITAT MANAGEMENT

David N. Allan[1] and Charles V. Bohart[2]

INTRODUCTION

The U.S. Department of Agriculture's Soil Conservation Service has provided leadership in the conservation development and productive use of the nation's soil, water, plant, and wildlife resources since 1935. Among SCS activities are erosion control, sediment reduction, pollution abatement, land use planning, multiple use, improvement of water quality, and several surveying and monitoring activities related to environmental improvement. All of these activities are designed to assure quality in the natural resource base for sustained use; quality in the environment to provide attractive, convenient, and satisfying places to live, work and play; and quality in the standard of living based on community improvement and adequate income. All SCS programs, directly and indirectly, may affect the habitat of nongame birds.

The Soil Conservation Service, in the process of executing its responsibilties, provides technical assistance designed to conserve soil, water, plant, and animal resources. Soil and water conservation receive the most attention because they are essential to the conservation of other resources. These resources include the habitat of nongame birds.

To wisely use soil and water resources, the Soil Conservation Service has developed about 130 conservation practices to assist landowners and operators. These practices range from construction and development of access roads to woodland site preparation. About 20 of the practices include wildlife among the purposes for installing the practice and three of them are designed solely for the improvement of wildlife habitat.

Technical standards and criteria have been established for all of these practices which provide guidance to assure meeting the purpose and quality for an adequate life expectancy. Standards and criteria are developed in consultation with universities, research institutions, individuals, and private firms and tempered with practical experience.

For example, "woodland improvement" is a practice that is being used in a number of states. Woodland improvement is the practice of removing unmerchantable or unwanted trees, shrubs, or vines from wooded areas. The practice is designed to fully use the potential of a site; to maintain plant cover for soil protection; to improve stand composition by leaving the best trees properly spaced for best growth; and to improve natural beauty, wildlife habitat, or recreational values. The practice is applied where a stand of trees is overstocked or where desirable trees are overtopped by less desirable trees, shrubs, or vines; where removing part of a stand will improve stand quality, forage production, or the recreation, wildlife, aesthetic, or hydrologic values of an area.

Standards and specifications for this practice usually include the following for wildlife:

1. Exceptionally attractive trees are preserved regardless of their value as crop trees.
2. Den trees, nut trees, cull and wolf trees are preserved because of their value to wildlife.
3. The growth of shrubs or other low growing vegetation around the edge of woodlots or plantation areas is favored.

The specifications for woodland improvement in Indiana require a 40-foot width of untreated woodland adjacent to open fields, highways or open water. This strip provides wind protection for the rest of the woodland; serves as an excellent food and cover site for wildlife, and contributes much to the beauty of the community. Plants such as dogwood, redbud, viburnums, black gum, sugar maple, serviceberry, sassafrass, sumac, Virginia creeper, and bittersweet are encouraged in the woods border.

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Other practices that provide habitat for nongame birds include conservation treatment of critically eroding areas and establishing field, farmstead and feedlot windbreaks, hedgerow plantings, and field borders. Practices designed specifically for wildlife include wildlife wetland habitat management and wildlife upland habitat management.

Environmental quality is an objective in all SCS practices, but getting wildlife requirements included in conservation practices depends a great deal on the landowner's degree of interest. Usually, their initial interest is in the economic opportunities of a practice or its effect upon soil and water conservation. District conservationists in some 3,000 soil and water conservation districts are the primary Soil Conservation Service contact with landowners and operators. Special consideration for wildlife is in their hands to a large degree. When the benefits of including wildlife options in conservation practices are identified, they are generally well accepted.

The potential of these practices to provide nongame wildlife habitat is shown by the total amounts installed. For instance, in 1977 woodland improvement was applied to nearly 300,000 acres (121,500 hectares) in the United States. A field windbreak is a strip or belt of trees or shrubs established in or adjacent to a field. Since the practice was started in the 1930's, the field windbreaks planted would circle the globe more than four times, some 174,000 kilometers in total length. Farmstead and feedlot windbreaks accounted for about 21,000 acres (8,500 hectares) of new woody plantings in 1977. Total acres established in this kind of woodland now exceeds 800,000 acres (324,000 hectares).

Planning for nongame birds in the northeast follows several avenues that are not totally forest oriented. In the heavily wooded region of the northeast, any manipulation of the forest affects many nongame species. Much of the forest is located in urban or suburban acres.

Most of northeastern land is in privately owned small woodlots. Much of this forest is located in the suburbs and the rural forest lands are often owned by retired or part-time residents. These persons have a broad interest in songbirds as evidenced by the many bird watching groups, carloads of bird seed sold, and plantings to attract birds.

Forestry practices normally planned with Soil Conservation District cooperators are not often primarily planned for wildlife, especially nongame birds. The planner often has to convince the landowner that forestry practices should be used to create the desired nongame bird habitat. The increased use of wood as fuel now provides the incentive needed to cut small openings, maintain woods roads, and to create cutback borders. Landowners are advised to leave the important fruit bearing trees and shrubs for wildlife purposes. They are encouraged to leave standing dead cull trees such as poplar and gray birch to provide nesting sites for woodpeckers, chickadees, and other cavity nesting birds. Leaving snags on den trees are encouraged and seeding wood roads and log decks to plants, such as Lathco flatpea, may maintain openings for over 20 years. These areas are used by doves, grouse, and for song bird nesting.

The release of old orchards or wild apple trees benefits both game and nongame species. The cavities in these trees are especially attractive to bluebirds. Information on top grafting apple trees to small fruited crab apples is becoming more popular. This is being done in old orchards and to the many wild apples that are normally found in woodland and hedgerows.

Bluebird trails are planned and installed by many landowners, conservation commissions, and schools with outdoor study areas. Outdoor study areas or "outdoor classrooms" are saving existing woodlands and create some new ones. Because young people learn about nongame birds and other wildlife, these areas are very important to this resource. The future welfare of wildlife, like so many other things, will pass to the hands of these people.

In New Hampshire, landowners along the large rivers are encouraged to leave elm and silver maple. The latter is a brittle tree that forms natural cavities for nesting. While these are used primarily by woodduck and goldeneyes, the cavities are also utilized by other birds.

The creation of small marshes and protection of beaver flowages create or preserve great blue heron rookeries. The standing dead trees are used by cavity nesting birds. Cooperators are encouraged to cutback the edge of marshes to create shrub borders for warblers and similar birds. Mowing is an important means of maintaining open land bird habitat. Mowing dates are typically from late July-on to allow ground nesting. Landowners are encouraged to do random mowings of old fields to create more edges and to leave pruned shrubs. A 5-year rotation is planned where each year a fallow strip is plowed to set back plant succession and encourage weedy growth for song bird feed.

The installation of many soil and water conservation practices on forested or wooded areas helps enhance the habitat needed by nongame birds. New habitat is created where practices provide for establishing woody plantings for a variety of purposes.

Landowners are encouraged to include specific considerations for wildlife when they install conservation practices. When this is done, the practices become even more important to nongame birds and other wildlife. Landowners are also encouraged to use the practices that have been designed solely to benefit wildlife.

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FORESTS AND WILDLIFE IN SOUTHERN MICHIGAN IN THE PAST AS COMPARED TO 1970-1978

Lawrence H. Walkinshaw[1]

Abstract.--Much of the original southern Michigan forest and wetland have been decimated. The land was used for crops and housing. The forests were used for lumber and fuel. The wildlife was used originally for survival. The result has been that in many regions only small woodlots remain. Some species, recently, such as Canada Geese and Sandhill Cranes have increased because of good management methods. Other species such as Red-winged Blackbirds have increased, regardless, while many other bird species have decreased reaching extinction in many communities. Yet fall migrants show no decrease. Could pesticides and herbicides have some effect on local populations.

INTRODUCTION

During the 1979 Non-Game Bird Workshop meeting in Minneapolis one of the most common themes was that regardless of the biotope, only a small percentage of the original now exists. Accordingly the birds using these habitats have decreased tremendously. In southern Michigan, one such example is the Blue-gray Gnatcatcher (Polioptila caerulea). In Calhoun County in a bottomland woods, C.E. Coles (Oologist, 1876, p. 31) found in 1876 75 nests during a single summer. Probably all the ornithologists in Michigan have not found that many nests during the past 40 years. The original forests are so decimated that some bird species have completely disappeared in many regions.

This change came after white people settled the land, and during a period of 150 years. My great-grandparents and grandparents were examples of pioneers that settled southern Michigan. They moved into the region from Scotland, England, New York, Pennsylvania, etc., cleared the forests, then farmed their newly acquired land. Some of the forest was used for lumber for their new homes, some was used for fuel. Some of the wildlife was used for food - for survival. Shortly after the first settlers arrived White-tailed Deer, Wild Turkeys and Passenger Pigeons disappeared completely.

These couples also had large families which in turn settled more and more land. However, by the time my parents began farming, they realized the value of woodlots and they began reforesting unfarmable regions such as steep hills, planting normally maples, oaks and elms. I also realized the value of wildlife and by 1916-1917 had a line of Bluebird houses on the wooden fenceposts around our fields.

Large families aided the pioneers but they made the world population skyrocket. For example, the seven families alone, belonging to my great-grandparents, grandparents and parents averaged seven children apiece while seven died in childhood. All of those remaining required their own home and land, as did each of their children. Families throughout the world during that period were increasing about the same rate.

Because of the automobile, highways were improved. Some were hard-surfaced. Travel became possible both summer and winter. Simultaneously many city dwellers moved to rural regions while many farmers commuted to city jobs. Consequently many regions became urbanized.

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LAND USE

Between 1910 and 1920 more land was farmed in southern Michigan than now. Much of this is the result of urbanization. Some people when purchasing land, allowed it to revert back to forest, marsh and grassland. Farming became mechanized. More commercial fertilizers were used and hybrid grains increased farm yields. With all of these less land was needed.

Difficulties in other parts of the world are often even more severe when it comes to land use whether it be for forests or farming.

Quote (I.U.C.N.,1978):

" At present about 2.5 million sq. km of drylands are used for irrigated agriculture and new lands are being irrigated at the rate of 2.9 % a year in the developing countries."

"Exacting standards are not always attained. It is estimated that about 50 % of dryland irrigated soils are suffering from salinization and 25 % from erosion."

They continued that rainfed agriculture has always been an important source of food. That with increased populations, especially following a sequence of years with good rains, people have taken chances. By using tractor drawn vehicles, they have farmed far beyond where advisable. In Niger, before the last drought, both cultivation and settlement pushed 100 miles north of the legal limit. In Tunisia 2.7 million ha of former steppes were cleared between 1890 and 1975. The result was the losses of indegenous vegetation, exerting greater pressure on soil that remained. At times there was a loss of soil structure, fertility and often the soil itself. In Rajasthan, India, sandstorms increased from 8 to 25 per annum during a 15 year period. With this loss of world land, an accompanying increase in deserts, which has recently been brought out (I.U.C.N.,loc.cit.), with the urbanization of more and more land, plus a tremendous increase in world population, greater pressure is put on remaining farm land and forest.

In many world regions the status of an individual has been considered by the size of his livestock herd. Often these herds have produced much damage to both plants and soil.

Quote (I.U.C.N.,1978):

" Whether in the rangelands of Australia and the United States or in the grazing pastures of Chile and North Africa, there is a natural reluctance to reduce livestock to match reduced pasture. And whether in the rich or in the poor lands, overgrazing plus drought is a deadly combination."

In many regions we have seen in Nigeria and Sudan these residents require fuel so that in some areas scattered trees and forests have suffered. Yet, human beings, as well as all other animals are almost totally dependent on the plant kingdom. Probably some forms of plants and animal life have never been known because they became extinct prior to our knowledge. Even now many are being or may be lost unless we make definite efforts to save them, and though we have commendable programs trying to save some species, others may be lost before we know their value.

Quote (I.U.C.N., 1978):

" Many of the plant species that are threatened today are, actually or potentially, the sources of valuable products. . . precious timbers such as Mexican mahogany (Swietenia humilis), and certain drug plants like the yam species,(Dioscorea deltoidea), a major source of diosgenin, the starting material for the manufacture of cortisone."

In northern Michigan many forests were clear-cut before our time, especially those of White Pine (Pinus strobus) and even now, 80-100 years later, some regions have never recovered. Many tracts of northern Michigan forestland are being purchased by individuals because of unfavorable living conditions in our cities. More and more people are building their first or second home in these forests. Some ecosystems we have known may be a thing of the past.

But our National and State Forests seem to be in good hands. And well organized research has, is and will aid wildlife species in these forests. This is being carried out by both biologists and foresters as shown at this and previous workshops. Some programs are in progress to aid endangered or threatened species, such as the Kirtland's Warbler (Dendroica kirtlandii). When we aid this species or any endangered species we are simultaneously aiding other wildlife species. We may even keep some other species from becoming rare.

TABLE 1

THE BREEDING BIRDS ON SIX ACRES (2.43 HECTARES) IN SECTION 7, LAKETON TOWNSHIP, MUSKEGON COUNTY, MICHIGAN

The region consisted of red, white and black oaks, sugar maple, beech, white pine and hemlock woods along the shore of Lake Michigan. It was 1,308 feet long and 200 feet wide with two driveways going to two houses. Censuses taken, 1950-1978.

No.	Species	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	Total	Nests
1.	Cooper's Hawk																					1N									1	1N
2.	Ruffed Grouse													x						x	x										Present	
3.	Mourning Dove																		1N	1	1N							1	1	1	6	2N
4.	Yellow-billed Cuckoo																			1N					1N						2	2N
5.	Black-billed Cuckoo								1N																						1	1N
6.	Screech Owl			1N			1																								2	1N
7.	Barred Owl	x	x	x																x	x	x									Present	
8.	Whip-poor-will	x	x	x	x																										Present	
9.	Ruby-throat.Hummingbird																				1N										1	1N
10.	Belted Kingfisher																						1N			1N					2	2N
11.	Red-headed Woodpecker						1N															1N	1N	1N	1N	1N	1N	1N	1N	1N	10	10N
12.	Crested Flycatcher																	1N													1	1N
13.	Eastern Phoebe															1N	1N	1N	1N	1N	1N	1N		1N							8	8N
14.	Acadian Flycatcher													x	x																Present	
15.	Least Flycatcher												x	x	x	1N	3N	3N	3N	4N	5N	4N	2N								25	25N
16.	E. Wood Pewee	4	2	3	3	3	4	3	3	2	3	3	3	3	3	3	3	3	3	3	3	4	3	3	2	1	2	2	1	1	79	32N
17.	Black-cap.Chickadee	x	x									1N									1Y										2	1N,1Y
18.	Tufted Titmouse												1																		1	
19.	White-breast.Nuthatch			1N	1N	1N	1N	1N	1N	1N															1	1N	1	1	1	1N	13	9N
20.	Gray Catbird								1N		1N																				2	2N
21.	American Robin	2	2	2	2	2	2	2	2N	3	3N	3N	3	3	3	2	2	2	3	2	7N	4N	3	3N	2N	2	2	4N	2N	2N	76	32N
22.	Wood Thrush																						1N								1	1N
23.	Cedar Waxwing		1N	1N																											2	2N
24.	Yellow-throated Vireo								1	1	1	3N	1	1																	8	3N
25.	Red-eyed Vireo	6	5	5	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	3	3	3	3	2	2	2	2	3	2	122	52N
26.	Black & Wh. Warbler	1Y																													1	1Y
27.	Cerulean Warbler													1N																	1	1N
28.	Pine Warbler	1N	1N	1	1	1	1	1	1																						8	2N
29.	Ovenbird	3	2	3	3	3	3	3	3	3	3	3	1	1																	34	2N
30.	American Redstart	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2	2	2	1	1									54	5N
31.	Brown-headed Cowbird	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	2	59	7E
32.	Scarlet Tanager	2	2									3N		2																	9	3N
33.	Cardinal	2	2	1	2	2	2	2	2	2	2N	2	2	2	2	1	2	2	2	2	2	1	1N	1	1	1	1	1N	1	1	47	4N
34.	Rufous-sided Towhee	1								1	1											1N	1N								5	2N
35.	Indigo Bunting	1	1	1																											3	
36.	Chipping Sparrow	4	3	3	3	3	3	3	3	5N	3	4N	3	3N	3	2N	2N	2N	2	2	2N	2N	1N	1N	2	1N	1N	1N	1N	1Y	69	28N,1Y
37.	Song Sparrow	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1Y	1Y	1Y	1Y	1Y	29	5Y
	Total Pairs	33	26	28	27	26	29	26	29	29	28	33	25	27	22	21	23	24	25	27	30	26	20	16	15	13	13	16	14	13	684	250N,Y
	Total Species	14	13	14	11	11	13	11	14	12	12	12	11	12	8	10	10	11	11	12	13	13	12	9	10	10	9	10	10	10	328 ,37	

THE FOREST BIRDS IN MUSKEGON COUNTY

Between Muskegon State Park and Pioneer Park, a distance of four miles, there is solid forest in Michigan. Between the two parks it is residential but still forested. Each residence, in most cases, is 100 feet from the next and each house has a driveway through the woods and some clearing around the dwelling. The properties vary some in length according to which direction both the road and lake go. We own one of these properties about halfway between the parks. It is 100 feet wide and 1,308 feet long. On this and the next lot of the same size, I have recorded the breeding birds since 1950. The studied area consisted of six acres (2.43 ha). On the west is Lake Michigan; on the east is Scenic Drive and across the road is solid forest. On the east end of our property and the next property, is a clearing 150 X 220 feet. It is grown mostly to scattered small trees, Sassafras (*Sassafras varifolium*), Red Oak (*Quercus rubra*), White Oak (*Q. alba*), a few planted pines (*Pinus sylvestris*), some Jack Pine (*P. banksiana*). Much of the ground is covered with Bracken Fern as are parts of the woods, with some Sweet Fern (*Comptonia peregrina*) and grasses. In the woods, the most common trees are Red Oak, White Oak, White Pine (*P. strobus*), Beech (*Fagus grandifolia*), *Sassafras*, lesser amounts of Hemlock (*Tsuga canadensis*), Black Cherry (*Prunus serotina*), Witch Hazel (*Hamamelis virginiana*), etc. Besides Bracken Fern, the ground cover is Blueberry (*Vaccinium* sp.), Wintergreen (*Gaultheria procumbens*), Trailing Arbutus (*Epigaea repens*) and many other plants. Only about 20 White Oaks (6 to 9 in. in diameter) and several dead White Pines have been removed during our ownership. Otherwise the forest has continued to grow. The understory has changed little and there has been no fires.

In general 1950-1952, 1967-1978 were rather wet years and 1953-1966 drier years. Coverage was made during all week-ends, 1950-1968 then almost daily much of May, July and August, 1969-1978. The species of birds observed during the 29 year period are listed in Table 1. Two Kingfisher (*Megaceryle alcyon*) nests were recorded in Table 1 but 57 Bank Swallows(*Riparia riparia*) were not, 1970,8; 1971,15; 1973,7; 1974,27. They were in the bank above Lake Michigan.

During the six year period, 1950-1955,inc. the mean number of breeding pairs was 28.1 (26-33). During the last six years, 1973-1978,inc., the mean number was 14.0 (13-16) indicating a trend which was reflected throughout the surrounding forest. Some species such as Cooper's Hawk (*Accipiter cooperii*), Screech Owl (*Otus asio*), Acadian Flycatcher (*Empidonax virescens*), all the *Parulidae*, have not been found in the vicinity for several years.

Simultaneously Cooper's Hawks, Piping Plover, Acadian Flycatchers and other birds disappeared from nearby woodlands and beach. With the above information it was found there were 391 (216-550) breeding pairs per 100 acres in Muskegon County oak-maple,white pine forest or 966 (534-1359) per ha, during this 29 year period. The mean number per 100 acres for the first six years, 1950-1955 inclusive was 468 pairs and for the period, 1973-1978, inclusive, it was 233 pairs (1,156 and 576 pairs per ha respectively).

With this decrease in breeding birds we have wondered about the migrants. From 1957 to date we have mist-netted birds during the fall migration. The numbers of birds banded during this period is shown in Table 2:

TABLE 2

THE NUMBER OF BIRDS MIST-NETTED

DURING THE FALL MIGRATION IN

LAKETON TWP.,MUSKEGON CO.,MICHIGAN

YEARS	BIRDS CAPTURED	NET HOURS	BIRDS CAUGHT PER NET HOUR
1957-1962	3,631	6,546	0.55468
1963-1968	5,799	9,179	0.63177
1969-1973	12,653	20,918	0.60488
1974-1978	7,083	11,798	0.60036
21 YR. TOTAL	29,166	48,441	0.60209

During two autumns the number of birds caught per net hour were higher than normal. During 1973, 2,294 birds were netted during 1,935 hours or 1.185 per net hour. During 1974, 1,715 were caught during 1,146 net hours, or 1.186 per net hour. The most common bird caught during this period was the Tennessee Warbler (*Vermivora peregrina*). The numbers captured per month are given in Table 3. During the first ten years, 604 of these birds were captured (1957-1966,inc.). During the last four years, 1975-1978, 668 were caught. During the years, 1970-1974, 2,402 were caught, 663 during late August 1972. This species has fluctuated in numbers reaching peaks, with the greatest peak in 1972.

TABLE 3

TENNESSEE WARBLERS MIST-NETTED IN THE FALL, LAKETON TWP., MUSKEGON CO., MICHIGAN

YEAR	AUGUST	SEPTEMBER	OCTOBER	TOTAL
1957	0	0	0	0
1958	25	4	2	31
1959	4	7	5	16
1960	0	3	0	3
1961	7	55	5	67
1962	17	11	2	30
1963	73	96	10	179
1964	8	47	50	105
1965	x	x	x	x
1966	50	104	18	172
1967	4	38	4	46
1968	x	x	x	x
1969	42	18	26	86
1970	87	231	4	322
1971	265	256	9	530
1972	663	76	18	757
1973	40	338	112	490
1974	20	222	61	303
1975	52	37	0	89
1976	12	182	0	194
1977	179	58	0	237
1978	82	65	1	148
TOTAL	1,630	1,848	327	3,805

It is evident that Tennessee Warblers and other migratory birds may fluctuate from year to year. If the entire migratory population is considered this may not be evident. There could be a similar fluctuation with breeding birds but it does not seem likely. Some species have disappeared completely from the entire area.

It is also evident that during recent years many other species of birds in eastern United States have increased. Examples are Canada Geese (*Branta canadensis*), Sandhill Cranes (*Grus canadensis tabida*), Blue Jays (*Cyanocitta cristata*), Ravens (*Corvus corax*), Brewer's Blackbirds (*Euphagus cyanocephalus*), Common Grackles (*Quiscalus quiscula*), Brown-headed Cowbirds (*Molothrus ater*) and Redwinged Blackbirds (*Agelaius phoeniceus*).

Canada Geese and Sandhill Cranes probably increased because of better management practices and because new refuges have been established for them to use. Many species have increased without any appreciable help except they make better use of the environment. Blue Jays make continuous use of feeders.they may have been also aided by the loss of predators.

Why then have many bird species decreased, throughout southern Michigan? Some species such as Prairie Chickens (*Tympanuchus cupido*) and Marsh Hawks (*Circus cyaneus*) are gone from Calhoun and surrounding counties. Their habitat looks unchanged. Even into the 1920's a bounty of 25 cents was paid on Marsh Hawks in Calhoun County. And even later than that flocks of 50 or more Prairie Chickens could be found. I found nests of both species there but did lose some hawk nests to bounty hunters, 1918 to 1930.

Poachers, the boy with an illegal gun, cats and dogs have always taken a toll of bird life. Domestic animals have increased in numbers but they certainly do not compare with former predators, many of which have also disappeared.

With some birds it could be their method of migration. Night migrants encounter many more hazards than were formerly present. Even during daytime they meet some of these hazards. Imagine how many birds lose their lives flying into television towers, power lines, tall buildings, picture windows and other man-made objects plus those killed by automobiles.

G.J. Wallace (1960, 1962), Wallace, Nickell and Bernard (1961), Hickey and Hunt (1960) and Mehner and Wallace (1959) and many others have shown that many birds have died from the use of pesticides, many forms of which came into use following World War II. I doubt if anyone can inform us the true effect of herbicides on wildlife. Apparently some species are susceptible to pesticides, possibly herbicides, while others are not. Otherwise all species would decrease in numbers where they are resident in Michigan's southern counties. The fact that migrants from farther north,where few or no pesticides are used, have not decreased makes it look as though this could be the cause for the continued decrease of many species of both *Parulidae* and *Fringillidae* and probably other groups of birds. The food some birds eat probably makes them more susceptible than others but this is hard to pin down.

Formerly the large number of birds found in southern Michigan helped keep insect pests, even some weed seeds,down. Such insect eaters as Tree Swallows (*Iridoprocne bicolor*) and other swallows have not decreased in my study areas and the Tree Swallow has practically replaced the Bluebird (*Sialia sialis*) in many regions. It appears as though we may lose certain species of birds whether we improve our forests or not while other species increase until they become pests.

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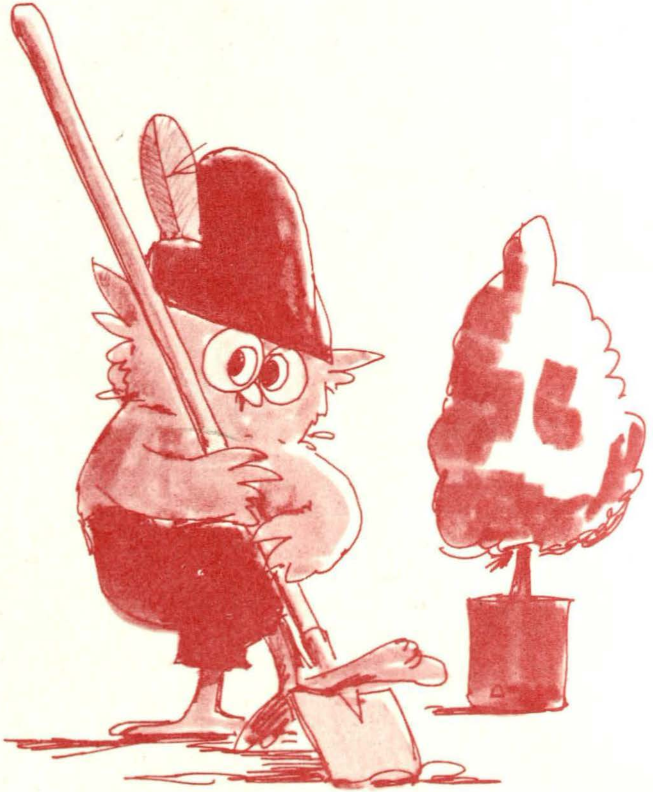

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